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VITAMIN B_1 NUTRITION IN SURGICAL PATIENTS AS DETERMINED BY THE BLOOD LEVEL OF PYRUVIC ACID

I. HEPATIC DISEASE

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NEW ORLEANS

Carboxylase is an enzyme which catalyzes the decarboxylation of pyruvic acid to carbon dioxide and water. It was first recognized by Neuberg and Karczag.[1] Auhagen[2] showed that the activity of carboxylase is dependent on the presence of a coenzyme which is known as cocarboxylase and which is found in animal tissues. Later Lohmann and Schuster[3] were able to isolate cocarboxylase and to demonstrate that it is a pyrophosphoric ester of vitamin B_1 (thiamine). Vitamin B_1 (thiamine) after ingestion is absorbed from the intestine by diffusion into the blood stream. It reaches the liver and the kidneys, where phosphorylation takes place and where the thiamine is stored as cocarboxylase, or diphosphothiamine (Ochoa and Peters[4]; Westenbrink and Goudsmit[5]). Dephosphorylation of the diphosphothiamine may take place in all of the tissues but appears to be carried out mainly in the liver and the kidneys (Ochoa[6]; Tauber[7]). Dephosphorylation results in the formation of free thiamine. This may be released into the blood stream, after which it is rephosphorylated by other tissues, or it may be excreted in the urine. It is thus evident that vitamin B_1 (thiamine) after absorption exists in two forms in the animal body either as free thiamine or as diphosphothiamine, most of it occurring in the latter form. Peters[8] demonstrated that thiamine is essential in the metabolism of pyruvic acid. Since pyruvic acid is a degradation product of carbohydrate metabolism, the importance of thiamine can be readily appreciated. It should be remembered, however, that free thiamine is inactive and that it is only diphosphothiamine which is capable of oxidizing pyruvic acid to carbon dioxide and water. Since the liver is an important storage depot for the active form of thiamine, namely diphosphothiamine, several interesting questions present themselves: What is the effect of thiamine on function of the liver, and what are the effects of diminished hepatic function on the physiologic availability of thiamine? In this regard certain observations are of interest. Tonutti and Wallraff[9] have shown that the livers of B_1-deficient mice are lacking in glycogen. This they said was due not to inanition but to inability of the livers of such mice to store glycogen. Similar observations were made by Hermann[10] in rats. Longenecker and his co-workers[11] found a diminution of fat in the livers of thiamine-deficient rats. The administration of thiamine to such rats caused an increase in the amount of fat in the liver. The purpose of the present study was to determine (1) the inci-

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1. Neuberg, C., and Karczag, L.: Ueber zuckerfreie Hefegärungen: IV. Carboxylase, ein neues Enzym der Hefe, Biochem. Ztschr. **36**:68-75, 1911.

2. Auhagen, E.: Ueber Co-Carboxylase: Reinigungsversuche und Vorkommen in tierischen Organen, Biochem. Ztschr. **258**:330-339, 1933.

3. Lohmann, K., and Schuster, P.: Ueber das Vorkommen der Adeninnucleotide in den Geweben; rote Blutkörperchen: Das Molekulargewicht der Adenylpyrophosphorsäure, Biochem. Ztschr. **294**:183-187, 1937.

4. Ochoa, S., and Peters, R. A.: Vitamin B_1 and Cocarboxylase in Animal Tissues, Biochem. J. **32**: 1501-1515 (Sept.) 1938.

5. Westenbrink, H. G. K., and Goudsmit, J.: Investigations on Aneurin and Cocarboxylase Content of Animal Tissues, Estimated by Thiochrome Method, Enzymologia **5**:307-320, 1938.

6. Ochoa, S.: Enzymic Synthesis of Cocarboxylase in Animal Tissues, Biochem. J. **33**:1262-1270 (Aug.) 1939.

7. Tauber, H.: Interaction of Vitamin B_1 in Enzymic Reactions, J. Biol. Chem. **123**:499-506 (April) 1938.

8. Peters, R. A.: Biochemical Lesion in Vitamin B_1 Deficiency; Application of Modern Biochemical Analysis in Its Diagnosis, Lancet **1**:1161-1165 (May 23) 1936.

9. Tonutti, E., and Wallraff, J.: Wirkstoffe und Glykogenspeicherungsvermögen der Leber, Ztschr. f. mikr.-anat. Forsch. **44**:532-550, 1938.

10. Hermann, V. S.: Ueber den Glykogengehalt der Leber B_1 avitaminotischer Ratten, Ztschr. f. physiol. Chem. **262**:95-102, 1939.

11. Longenecker, H. E.; Gavin, G., and McHenry, E. W.: Fatty Acids Synthesized by the Action of Thiamine, J. Biol. Chem. **134**:693-699 (July) 1940.

dence of B_1 deficiency in patients proved to be suffering from hepatic disease and (2) the response of patients with hepatic disease to the administration of vitamin B_1.

METHODS AND MATERIALS

A series of 32 patients suffering from various forms of hepatic disease was used. Most of these patients showed definite jaundice of varying degree. Routine studies of the blood, the urine and the stools were carried out. The renal function and the blood levels of urea nitrogen and nonprotein nitrogen were determined for each patient. Hepatic function was estimated by the cephalin flocculation test, the intravenous hippuric acid test and the bromsulphalein test. The pyruvic acid content of the blood was determined by the method of Lu[12] with the Klett-Summerson photoelectric colorimeter. Additional studies made were as to the Kline and the Kolmer reaction, the prothrombin content of the blood, the van den Bergh reaction, the total serum proteins, the serum albumin and the serum globulin. Roentgen studies of the gallbladder and of the gastrointestinal tract were carried out when indicated. A control group of 30 surgical patients suffering from minor ailments unassociated with fever was used (referred to later as "normal" patients). To determine the response of persons suffering from hepatic disease to the administration of vitamin B_1 the blood levels of pyruvic acid were determined before, and three hours after, the intramuscular injection of a standard amount of thiamine hydrochloride. Standard doses of 50 mg. or 100 mg. of thiamine hydrochloride were used. As controls, the levels of pyruvic acid in the blood of 6 "normal" patients were determined before and after the administration of equal amounts of thiamine hydrochloride.

RESULTS

Of 32 persons suffering from various forms of hepatic disease, 27 showed definite evidence of vitamin B_1 deficiency as revealed by elevations of the blood levels of pyruvic acid. These levels varied from 1.5 to 4.25 mg. per hundred cubic centimeters (table 1.) In the control series of patients the blood levels of pyruvic acid varied from 0.5 to 1.3 mg. per hundred cubic centimeters. Further analysis of the data was rendered difficult by the fact that in many patients hepatic disease was accompanied by fever, malnutrition or both. In an effort to evaluate the effects of diminished hepatic function, fever and malnutrition on the blood levels of pyruvic acid the patients were arranged in four groups. In group 1 were 11 patients suffering from hepatic disease unaccompanied by fever or malnutrition. In group 2 were 10 patients suffering from hepatic disease with fever but without malnutrition. In group 3 were 4 patients suffering from hepatic disease accompanied by malnutrition but not by fever. In group 4 were 5 patients suffering from hepatic disease accompanied by fever and malnutrition. Each of these groups were further subdivided into (*a*) patients showing definite evidence of diminished hepatic function as revealed by tests for hepatic function and (*b*) patients in whom such tests revealed normal hepatic func-

TABLE 1.—*Blood Levels of Pyruvic Acid in Hepatic Disease*

Patient	Age	Diagnosis	Fever	Nutrition	Icterus Index	Cephalin Flocculation Test	Hippuric Acid Test, Gm.	Pyruvic Acid in Blood, Mg. per 100 Cc.
W ♀	52	Portal cirrhosis	0	Good	66.5	3+	0.27	3.0
W ♀	44	Cholangitis	+	Good	24.0	...	....	3.0
C ♂	24	Arsenical hepatitis	0	Good	140.0	...	0.86	1.85
W ♂	52	Obstructive jaundice due to retroperitoneal sarcoma	0	Good	126.0	...	0.6	2.0
W ♀	50	Cholangitis and hepatitis	+	Good	56.0	3+	....	2.25
C ♀	37	Obstruction of common bile duct	0	Good	16.0	0	0.77	0.85
C ♂	71	Carcinoma of head of pancreas	0	Poor	101.0	2+	0.4	2.25
W ♂	44	Amebic abscess of liver	+	Good	74.0	3+	0.36	4.25
W ♂	47	Portal cirrhosis	0	Good	208.0	3+	0.5	2.2
C ♀	52	Cholangitis and hepatitis	+	Good	126.0	3+	0.45	2.6
C ♀	42	Stone in common bile duct	0	Good	125.0	...	0.83	1.4
W ♂	48	Carcinoma of head of pancreas	0	Poor	62.5	0	0.14	2.5
W ♂	49	Weil's disease	+	Good	113.0	...	0.42	3.0
W ♂	58	Obstructive jaundice due to retroperitoneal tumor	+	Good	50.0	...	0.7	0.48
W ♂	49	Hepatoma	0	Good	8.0	0	0.75	2.0
W ♂	53	Portal cirrhosis	0	Poor	12.5	0	0.3	2.2
W ♂	61	Portal cirrhosis	0	Good	43.0	2+	0.56	1.8
W ♂	68	Portal cirrhosis	+	Poor	62.0	4+	0.48	1.9
W ♂	46	Portal cirrhosis	0	Poor	10.0	0	0.6	2.4
W ♂	52	Portal cirrhosis	0	Good	20.0	0	0.6	1.8
W ♂	48	Hepatitis	+	Good	60.0	2+	0.5	2.5
W ♂	64	Neoplastic obstruction of common bile duct	+	Good	68.0	0	0.8	2.0
W ♂	38	Portal cirrhosis	+	Good	32.0	2+	0.28	1.5
W ♂	71	Hepatoma	0	Poor	9.0	0	0.85	1.5
W ♂	50	Portal cirrhosis	+	Poor	12.0	1+	0.58	1.5
W ♂	68	Catarrhal jaundice	+	Poor	40.0	2+	0.6	1.6
W ♂	32	Amebic abscess	+	Poor	45.0	2+	0.75	1.6
C ♂	68	Weil's disease	+	Good	40.0	0	0.8	2.3
W ♂	71	Carcinoma of pancreas	0	Good	65.0	0	0.85	0.6
C ♀	38	Catarrhal jaundice	+	Good	62.0	0	0.8	1.5

12. Lu, G. D.: Studies on Metabolism of Pyruvic Acid in Normal and Vitamin B_1 Deficient States: Rapid Specific and Sensitive Method of Estimation of Blood Pyruvate, Biochem. J. **33**:249-254 (Feb.) 1939.

tion. The results are tabulated in table 2. In groups 1, 2 and 3 those patients with clinical evidences of diminished hepatic function showed consistently higher blood levels of pyruvic acid. This suggests that diminished hepatic function may be one factor determining the elevation of the blood level of pyruvic acid in disease of the liver. A more detailed statistical analysis of these groups is presented in table 3. In patients having definite evidences of decreased hepatic function fever does not appear to cause a statistically significant increase in the pyruvic acid of the blood (column A, table 3). Decreased hepatic function is associated with increased content of pyruvic acid in the blood. This increase is statistically significant (column B, table 3). The blood level of pyruvic acid in patients with decreased hepatic function and malnutrition is not significantly higher than that in the group without evidences of malnutrition (column C, table 3). Finally, if the patients are divided into two groups, those with decreased hepatic function and those with normal hepatic function, it is found that in the former group there are consistently higher blood levels of pyruvic acid and that the difference is statistically significant. The second part of this investigation was concerned with a comparison of the response evidenced by reduction of the blood level of pyruvic acid to vitamin B_1 administered by intramuscular injection to "normal" patients and to those suffering from hepatic disease.

TABLE 2.—*Evaluation of Effects of Diminution of Hepatic Function, Fever and Malnutrition on Blood Levels of Pyruvic Acid in Hepatic Disease*

Group 1 (11 Patients Without Fever or Malnutrition)		Group 2 (10 Patients With Fever but No Malnutrition)		Group 3 (4 Patients With Malnutrition but No Fever)	
(a) With Diminished Hepatic Function	(b) With Normal Hepatic Function	(a) With Diminished Hepatic Function	(b) With Normal Hepatic Function	(a) With Diminished Hepatic Function	(b) With Normal Hepatic Function
Pyruvic Acid in Blood, Mg. per 100 Cc.	Pyruvic Acid in Blood, Mg. per 100 Cc.	Pyruvic Acid in Blood, Mg. per 100 Cc.	Pyruvic Acid in Blood, Mg. per 100 Cc.	Pyruvic Acid in Blood, Mg. per 100 Cc.	Pyruvic Acid in Blood, Mg. per 100 Cc.
3.0	1.85	2.25	0.48	2.8	1.5
2.0	0.85	4.25	2.0	2.2	
2.2	1.4	2.6	2.3	2.4	
1.8	0.6	3.0	1.5		
1.8	0.8	2.5			
	2.0	1.5			
Av. 2.16	Av. 1.25	Av. 2.68	Av. 1.57	Av. 2.46	Av. 1.5

Note.—Data on group 4 (patients with fever and malnutrition) are not included since all showed diminished hepatic function.

The mean reduction in the pyruvic acid of the blood in "normal" patients three hours after the intramuscular injection of 50 mg. of thiamine hydrochloride was 0.28 ± 0.074 mg. per hundred cubic centimeters. Injection of equal amounts in patients with hepatic disease but with normal hepatic function resulted in a greater reduction of the pyruvic acid of the blood, the mean being 0.6 ± 0.215 mg. per hundred cubic centimeters. This difference is statistically significant (horizontal column A table 4). However in patients with hepatic disease and decreased hepatic function the mean reduction is only 0.13 ± 0.099 mg. per hundred cubic centimeters. This response is statistically not significantly different from that which occurred in "normal" patients (horizontal column B, table 4). This is borne out by a comparison of the response to 50 mg. of thiamine hydrochloride in patients with normal hepatic function with that in patients who had decreased hepatic function. In the former group the mean reduction of the pyruvic acid in the blood is significantly greater (horizontal column C, table 4).

As might be expected, the administration of 100 mg. of thiamine hydrochloride to "normal" patients leads to a greater mean reduction of pyruvic acid in the blood, 0.52 ± 0.274 mg. per

TABLE 3.—*More Detailed Statistical Analysis of Groups in Table 2*

	Group	Number of Patients	Pyruvic Acid in Blood, Mg. per 100 Cc., Mean	Difference Between Means *	t	P
A.	Patients with diminished hepatic function without fever	5	2.16 ± 0.445			
	Patients with diminished hepatic function with fever	6	2.68 ± 0.697	0.52	1.12	>0.2
B.	Patients with normal hepatic function without fever	6	1.25 ± 0.536			
	Patients with diminished hepatic function without fever	5	2.16 ± 0.445	0.91	2.716	<0.02
C.	Patients with diminished hepatic function without fever or malnutrition	5	2.16 ± 0.445			
	Patients with diminished hepatic function with malnutrition but no fever	3	2.46 ± 0.249	0.3	0.92	>0.3
D.	Patients with normal hepatic function	11	1.38 ± 0.595			
	Patients with diminished hepatic function	18	2.27 ± 0.537	0.89	4.009	<0.01

* Standard deviation $= \sqrt{\frac{\Sigma\Delta^2}{N}}$. P is derived from Fisher's table of t (Fisher, R. A.: Statistical Methods for Research Workers, London, Oliver & Boyd, Ltd., 1938). The difference between the means of two groups is significant if P is <0.05. Correction was made for small samples.

hundred cubic centimeters, than does the administration of 50 mg. of thiamine hydrochloride (horizontal column D, table 4). Moreover, this reduction is greater than that occurring in patients with decreased hepatic function (horizontal column E, table 4). The mean reduction of pyruvic acid in the blood after administration of 100 mg. of thiamine hydrochloride is greater in patients whose hepatic function is normal, 0.7 ± 0.353 mg. per hundred cubic centimeters, than in those whose hepatic function is decreased, 0.11 ± 0.07 mg. per hundred cubic centimeters. This difference is statistically significant (horizontal column E, table 4).

TABLE 4.—*Alteration of Blood Levels of Pyruvic Acid in Controls* and in Patients with Hepatic Disease After Parenteral Administration of Vitamin B_1*

Group	Number of Patients	Amount of Thiamine Hydrochloride Injected Intramuscularly, Mg.	Decrease in Pyruvic Acid in Blood, Mg. per 100 Cc., Mean	Difference Between Means †	t	P
A. Controls	5	50	0.28 ± 0.074			
Patients with hepatic disease and normal hepatic function	3	50	0.6 ± 0.215	0.32	2.64	<0.05
B. Controls	5	50	0.28 ± 0.074			
Patients with hepatic disease and diminished hepatic function	3	50	0.13 ± 0.099	0.15	2.14	>0.05
C. Patients with hepatic disease and normal hepatic function	3	50	0.6 ± 0.215			
Patients with hepatic disease and diminished hepatic function	3	50	0.13 ± 0.099	0.47	3.906	<0.01
D. Controls	2	100	0.52 ± 0.274			
Patients with hepatic disease and normal hepatic function	4	100	0.7 ± 0.353	0.18	0.514	>0.6
E. Patients with hepatic disease and normal hepatic function	4	100	0.7 ± 0.353			
Patients with hepatic disease and diminished hepatic function	5	100	0.11 ± 0.07	0.59	2.78	<0.05

* Surgical patients with minor conditions unassociated with fever ("normal" patients).
† Correction was made for small samples.

COMMENT

Since these results indicate a state of vitamin B_1 deficiency in patients suffering from various diseases of the liver, the question arises: Can a deficiency of vitamin B_1 itself produce hepatic damage? Biskind and Biskind [13] have found that a deficiency of the vitamin B complex in rats diminishes the ability of their livers to inactivate implanted estrone (theelin). György and Goldblatt [14] found that the livers of rats kept on a vitamin B-deficient diet undergo certain pathologic changes, specifically fatty degeneration, focal and massive necrosis, hyperemia and hemorrhage. These changes were due not to deficiency of vitamin B_1 but to deficiency of some other part of the B complex, possibly B_2. Other workers, also, have noted hepatic damage in animals fed a diet deficient in factors of the B complex; e. g., Sebrell [15] produced fatty infiltration of the liver in dogs, and Rhoads and Miller [16] found evidences of hepatic dysfunction in dogs suffering from experimentally induced "black tongue." Apart from the reduction in the glycogen and fat content of the liver in B_1 deficiency there appears to be no evidence to suggest that B_1 deficiency alone results in hepatic damage. Our results, on the other hand, indicate that the reverse situation may occur, namely, that hepatic damage can predispose to a state of B_1 deficiency. It is of interest to inquire into the mechanism whereby hepatic damage predisposes to B_1 deficiency. Clearly it is not due to a diminution of intake, since this would affect all of the patients and would not explain the difference in blood levels of pyruvic acid between patients presenting evidences of diminished hepatic function and those presenting evidence of unaltered hepatic function. There may be a defect in the absorption of vitamin B_1 from the intestine in patients with hepatic damage. Machella and Elsom [17] found that the urinary excretion of thiamine after it had been administered orally was lowered in patients with portal cirrhosis of the liver. They attributed this to diminished intestinal absorption. Undoubtedly, this may play a role, but it is probably not the only factor. The data already presented in this paper indicate that the reduction of py-

13. Biskind, M. S., and Biskind, G. R.: Diminution in Ability of the Liver to Inactivate Estrone in Vitamin B Complex Deficiency, Science **94**:462 (Nov. 14) 1941.

14. György, P., and Goldblatt, H.: Hepatic Injury on a Nutritional Basis in Rats, J. Exper. Med. **70**: 185-192 (Aug.) 1939.

15. Sebrell, W. H.: "Yellow Liver" of Dogs (Fatty Infiltration) Associated with Deficient Diets, Bulletin 162, National Institute of Health, United States Treasury Department, Public Health Service, 1933, pp. 23-35.

16. Rhoads, C. P., and Miller, D. K.: Hepatic Dysfunction in Dogs Fed Diets Causative of Black Tongue, J. Exper. Med. **67**:463-467 (March) 1938.

17. Machella, T. E., and Elsom, K. O.: Urinary Excretion of Ingested Thiamine in Patients with Chronic Hepatic Disease, Am. J. M. Sc. **202**:512-516 (Oct.) 1941.

ruvic acid in the blood after administration of thiamine is significantly less in patients with reduced hepatic function than in those whose hepatic function is normal. This would suggest that the liver itself may be at fault. Since phosphorylation of vitamin B_1 takes place in the liver, as has been shown by Ochoa and Peters [4] and by Westenbrink and Goudsmit,[5] it is suggested that phosphorylation of vitamin B_1 is diminished in certain forms of hepatic disease. Thus, less thiamine would be available physiologically for utilization by the tissues, leading to an elevation of the blood level of pyruvic acid and to other evidences of vitamin B_1 deficiency.

SUMMARY AND CONCLUSIONS

Thirty-two patients suffering from various forms of hepatic disease were studied as was also a control group of 30 surgical patients who had minor conditions unassociated with fever ("normal" patients). Vitamin B_1 deficiency as revealed by elevated blood levels of pyruvic acid was present in 28 of the 32 patients. Fever, malnutrition and diminished hepatic function, as determined by various clinical tests, frequently accompany hepatic disease. The reduction of hepatic function appears to be the most significant etiologic factor underlying the elevation of the blood level of pyruvic acid in such patients. Following the intramuscular injection of a standard dose of thiamine hydrochloride, the pyruvic acid in the blood diminishes both in normal persons and in patients with hepatic disease. The decrease in the pyruvic acid of the blood after administration of vitamin B_1 is significantly less when hepatic function is diminished. It is suggested that hepatic disease when associated with diminished hepatic function is a primary factor in inducing a state of vitamin B_1 deficiency, because of diminished hepatic capacity to phosphorylate vitamin B_1 and thus render it available for utilization by the tissues.

VITAMIN B_1 NUTRITION IN SURGICAL PATIENTS AS DETERMINED BY THE BLOOD LEVEL OF PYRUVIC ACID

II. THYROID DISEASE

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A considerable diversity of opinion exists regarding the relationship between vitamin B_1 and the function of the thyroid gland. It was not until Cowgill [1] demonstrated that the vitamin B_1 requirement of man is increased by elevation of the metabolic rate that the role played by this vitamin in thyrotoxicosis became the subject of much study. The purpose of the present investigation was to determine the nutritional status with respect to vitamin B_1 of persons suffering from toxic and nontoxic thyroid disease. The consistent rise in the pyruvic acid of the blood in vitamin B_1 deficiency provides a quantitative method of estimating the extent of this deficiency.

METHODS AND MATERIALS

Immediately on admission of the patient to the hospital the pyruvic acid content of the blood was determined by the method of Lu [2] with a Klett-Summerson photoelectric colorimeter. Hepatic function was estimated by the intravenous hippuric acid test or by the galactose tolerance test. Metabolic and blood chemical studies were carried out routinely on all of the patients with thyroid disease. A series of 23 patients was used, of whom 16 were suffering from toxic and 7 from nontoxic thyroid disease. A control series was used consisting of 30 surgical patients suffering from various minor ailments unassociated with fever. All of the patients having thyroid disease were subjected to operation, so that it was possible to verify histologically the lesion in each gland. All of the thyrotoxic patients were placed on a high carbohydrate, high protein and low fat diet (2,000 calories daily).

RESULTS

The control series was composed of 14 white and 16 Negro patients suffering from minor nonfebrile conditions and varying in age from 18 to 60 years. In this group the pyruvic acid content of the blood ranged from 0.5 mg. to 1.3 mg. per hundred cubic centimeters. These values are somewhat higher than those obtained by Lu [2] but are similar to those found by Bueding and Wortis.[3] Seven patients with nontoxic goiter exhibited blood levels of pyruvic acid varying from 0.45 mg. to 1.3 mg. per hundred cubic centimeters. In 16 cases of thyrotoxicosis associated with nodular or diffuse goiter the pyruvic acid content of the blood varied from 1.45 mg. to 3.5 mg. per hundred cubic centimeters (table 1). While all of these values were definitely raised, there did not appear to be an exact correlation between the increase of the metabolic rate or of the pulse rate and that of the pyruvic acid in the blood (table 1). Likewise, there did not appear to be any correlation between the pyruvic acid content of the blood and the type of toxic goiter present, whether diffuse or nodular. These data appear to suggest that vitamin B_1 malnutrition exists in patients suffering from thyrotoxicosis as revealed by elevation of the blood levels of pyruvic acid.

TABLE 1.—*Blood Levels of Pyruvic Acid in Thyrotoxicosis*

Patient	Color	Age	Sex	Type of Goiter	Pulse Rate	Basal Metabolic Rate	Pyruvic Acid in Blood, Mg. per 100 Cc.
D. M.	Negro	18	F	Diffuse toxic	120	+72	1.8
N. H.	Negro	27	F	Diffuse toxic	140	+75	1.6
K. G.	Negro	32	F	Diffuse toxic	116	+25	1.65
W. S.	Negro	21	M	Diffuse toxic	100	+19	1.5
L. R.	Negro	54	F	Diffuse toxic	140	+60	1.65
M. T.	White	33	F	Diffuse toxic	130	+59	3.5
R. B.	White	37	M	Nodular toxic	120	+38	1.8
B. F.	White	27	M	Diffuse toxic	120	+14	1.8
M. G.	White	55	M	Nodular toxic	120	+51	2.26
O. D.	White	30	F	Diffuse toxic	124	+41	1.45
C. B.	White	38	F	Nodular toxic	100	+15	1.6
E. G.	White	19	F	Diffuse toxic	120	+38	1.8
M. E.	White	40	F	Diffuse toxic	140	+28	1.9
M. G.	Negro	52	F	Diffuse toxic	124	+26	1.8
I. H.	Negro	26	F	Diffuse toxic	130	+30	2.1
C. F.	Negro	56	F	Diffuse toxic	140	+50	2.4

It was now necessary to investigate the effect of treatment on the blood levels of pyruvic acid. For this purpose two groups of patients were used. To one group strong solution of iodine U. S. P. and vitamin B_1 (thiamine hydrochlo-

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1. Cowgill, G. R.: Vitamin B Requirement of Man, New Haven, Conn., Yale University Press, 1934.

2. Lu, G. D.: Studies on Metabolism of Pyruvic Acid in Normal and Vitamin B_1-Deficient States: Rapid, Specific and Sensitive Method for Estimation of Blood Pyruvate, Biochem. J. **33**:249-254 (Feb.) 1939.

3. Bueding, E., and Wortis, H.: The Stabilization and Determination of Pyruvic Acid in the Blood, J. Biol. Chem. **133**:585-591 (April) 1940.

ride) were given in addition to the diet already described. The second group received the same diet and strong solution of iodine U. S. P. only. The results obtained in these two groups are illustrated in table 2. Before treatment the mean value for pyruvic acid in the blood of 11 patients was 1.84 ± 0.563 mg. per hundred cubic centimeters. After treatment with strong solution of iodine (0.9 cc. three times a day) and thiamine hydrochloride (10 mg. three times a day) the value for pyruvic acid in the blood dropped to 1.12 ± 0.302 mg. per hundred cubic centimeters. This difference in values for pyruvic acid is statistically significant (table 2) and is not due to errors of sampling. The second group of patients before treatment had a mean value for pyruvic acid in the blood of 2.0 ± 0.228 mg. per hundred cubic centimeters. After treatment with strong solution of iodine U. S. P. alone the value for pyruvic acid fell to 1.64 ± 0.1 mg. per hundred cubic centimeters. This decrease is statistically significant and not due to errors of sampling (table 2). In both groups there was a concomitant reduction of the basal metabolic rate and pulse rate, but this reduction was not quantitatively related to the fall in the blood pyruvic acid. A comparison of the blood levels of pyruvic acid after treatment with strong solution of iodine U. S. P. only and after treatment with this solution plus vitamin B_1 shows that there is no significant difference (table 2). Eight days after subtotal thyroidectomy had been performed the blood levels of pyruvic acid were again determined. At this interval after thyroidectomy some patients exhibited a fall in pyruvic acid. However, many showed an elevation which was statistically significant (table 2). Finally, it was of interest to determine whether or not the elevations of the pyruvic acid in the blood of thyrotoxic patients were affected by race. No significant difference could be found between white and Negro patients (table 2).

TABLE 2.—*Response of Blood Levels of Pyruvic Acid in Thyrotoxic Patients to Treatment*

Time of Determination in Relation to Treatment	Number of Patients	Pyruvic Acid in Blood, Mg. per 100 Cc., Mean	Difference Between Means *	t	P
White patients (before treatment)	8	1.975 ± 0.623			
Negro patients (before treatment)	8	1.812 ± 0.279	0.163	0.631	>0.05
Before treatment	11	1.84 ± 0.563			
After treatment (thiamine hydrochloride and strong solution of iodine U. S. P.)	11	1.12 ± 0.302	0.72	3.52	<0.01
Before treatment	5	2.0 ± 0.228			
After treatment (strong solution of iodine U. S. P.)	5	1.64 ± 0.1	0.36	2.9	<0.02
Before thyroidectomy	10	1.16 ± 0.31			
8 days after thyroidectomy	10	1.35 ± 0.23	0.19	2.73	<0.02
		Decrease in Blood Pyruvic Acid, Mg. per 100 Cc., Mean			
After treatment (thiamine hydrochloride and strong solution of iodine U. S. P.)	11	0.66 ± 0.33			
After treatment (strong solution of iodine U. S. P.)	5	0.36 ± 0.17	0.3	1.754	>0.05

* Correction has been made for small samples. P is derived by use of Fisher's table of t (Fisher, R. A.: Statistical Methods for Research Workers, London, Oliver & Boyd, Ltd., 1938). The difference between the means of two groups is significant if P is <0.05.

COMMENT

The results which have been presented strongly suggest that a disturbance of the carbohydrate metabolism leading to an accumulation of pyruvic acid in the blood occurs in thyrotoxicosis. A considerable amount of speculation has arisen regarding the exact role played by vitamin B_1 deficiency in thyrotoxicosis. Certain workers, such as Sure and Buchanan [4] and Peters and Rossiter,[5] have expressed the belief that vitamin B_1 physiologically counteracts the effects of thyroxin. On the other hand, Elmer and his coworkers,[6] Gentzen and Mohr [7] and Parade [8] cannot find any physiologic antagonism between vitamin B_1 and thyroxin. The controversy is still unsettled. Drill [9] has shown that the amount of vitamin B_1 in rat tissues is reduced by feeding thyroid gland. It is well known that a diminu-

4. Sure, B., and Buchanan, K. S.: Antithyrogenic Action of Crystalline Vitamin B_1, J. Nutrition **13**: 513-519 (May) 1937.

5. Peters, R. A., and Rossiter, R. J.: Thyroid and Vitamin B_1, Biochem. J. **33**:1140-1150 (July) 1939.

6. Elmer, A. W.; Giedosz, B., and Scheps, M.: L'action de la vitamine B_1 dans l'hyperthyréose expérimentale, Compt. rend. Soc. de biol. **126**:1037-1038, 1937.

7. Gentzen, G., and Mohr, T.: Experimenteller Beitrag zur Frage der Beziehungen zwischen Vitamin B_1 und Schilddrüse, Klin. Wchnschr. **17**:1243-1245 (Sept. 3) 1938.

8. Parade, G. W.: Der Einfluss der Schilddrüsenverabreichung bei Hunger und Vitamin B_1-Mangel, Ztschr. f. Vitaminforsch. **7**:40-45 (Jan.) 1938.

9. Drill, V. A.: The Effect of Experimental Hyperthyroidism on the Vitamin B_1 Content of Some Rat Tissues, Am. J. Physiol. **122**:486-490 (May) 1938.

tion of hepatic function frequently is present in thyrotoxicosis. The question arises: Is this diminution related to the disturbance of carbohydrate metabolism either as a cause or as an effect? Drill and his co-workers [10] have presented evidence indicating that the reduction of hepatic function in dogs with hyperthyroidism can be delayed by supplemental administration of vitamin B_1 and yeast. The relationship of vitamin B_1 to hepatic function and hepatic disease has been discussed more fully in the first paper of this series. Certain other factors are present in thyrotoxicosis which serve to intensify the nutritional deficit with respect to vitamin B_1. Hardt and Still [11] have shown that 5 to 15 per cent of ingested vitamin B_1 is lost in the sweat. Since patients with thyrotoxicosis perspire freely, a considerable amount of vitamin B_1 may be lost in this way. This loss is not compensated for by diminution in the output of vitamin B_1 in the urine. Another factor accentuating the lack of vitamin B_1 is the high carbohydrate diet which is customarily administered to such patients prior to operation. Environmental temperatures affect vitamin B_1 requirements. Mills [12] has pointed out that the higher the environmental temperature the greater the need for vitamin B_1. He has estimated that the optimal requirement for vitamin B_1 per gram of food is twice as high at 91 F. as it is at 65 F. The intolerance of the severely thyrotoxic patient for heat and the well known increased tendency toward thyroid crisis exhibited during the summer by thyrotoxic patients living in tropical and subtropical climates may be due in part to a heat-accentuated deficiency of vitamin B_1. In the data which we have presented the group of patients receiving vitamin B_1 in addition to strong solution of iodine U. S. P. did not show a greater diminution of pulse rate or of metabolic rate than did the group of patients who received only strong solution of iodine. This is in agreement with the work of Frazier and his co-workers.[13]

The elevation of the blood level of pyruvic acid exhibited by some patients during the first few days after subtotal thyroidectomy merits further discussion. This suggests that subtotal thyroidectomy itself may precipitate a minor degree of vitamin B_1 deficiency. Pollack and his co-workers [14] have reported the occurrence of ariboflavinosis after surgical operation. Our results would seem to indicate the advisability of administering increased amounts of vitamin B_1 and possibly of other members of the B complex to thyrotoxic patients after surgical operation.

SUMMARY AND CONCLUSION

The nutritional status with respect to vitamin B_1 of 23 patients suffering from thyroid disease was studied. A control series of 30 relatively normal patients was used. The blood level of pyruvic acid in the control patients ranged from 0.5 mg. to 1.3 mg. per hundred cubic centimeters. Seven patients suffering from nontoxic goiter showed blood levels of pyruvic acid varying from 0.45 mg. to 1.3 mg. per hundred cubic centimeters, which are normal values. Sixteen patients suffering from toxic diffuse goiter or toxic nodular goiter revealed blood levels of pyruvic acid which varied from 1.45 mg. to 3.5 mg. per hundred cubic centimeters.

No significant differences were noted between the blood levels of pyruvic acid in Negro and in white patients. The administration of strong solution of iodine U. S. P. alone results in a definite reduction of the pyruvic acid in the blood. Similarly, the administration of this solution and vitamin B_1 results in a decrease in the pyruvic acid of the blood, this decrease being statistically significant. Subtotal thyroidectomy may induce temporarily an increased need for vitamin B_1 as revealed by postoperative elevation of the blood level of pyruvic acid.

10. Drill, V. A., and Hays, H. W.: Studies on the Relation of the Liver Function, Pulse Rate and Temperature of Hyperthyroid Dogs to Vitamin B_1 and Yeast, Am. J. Physiol. **136**:762-771 (July) 1942. Drill, V. A.; Schaffer, C. B., and Overman, R.: Liver Function, Pulse Rate and Temperature of Hyperthyroid Dogs, ibid. **138**:370-377 (Jan.) 1943.

11. Hardt, L. L., and Still, E. U.: Thiamin in Sweat, Proc. Soc. Exper. Biol. & Med. **48**:704-707 (Dec.) 1941.

12. Mills, C. A.: Environmental Temperatures and Thiamine Requirements, Am. J. Physiol. **133**:525-531 (July) 1941.

13. Frazier, W. D.; Brown, R. B., and Vars, H. M.: The Influence of the B Complex and Certain of Its Components on Experimental and Clinical Hyperthyroidism, Tr. Am. A. Study Goiter, 1939, pp. 247-255.

14. Pollack, H.; Ellenberg, M., and Dolger, H.: Postoperative Precipitation of Vitamin B Complex Deficiencies, J. Mt. Sinai Hosp. **8**:925-932 (Jan.-Feb.) 1942.

VITAMIN B_1 NUTRITION IN SURGICAL PATIENTS AS DETERMINED BY THE BLOOD LEVEL OF PYRUVIC ACID

III. RENAL DISEASE, NEOPLASTIC DISEASE AND INFECTION

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It has been shown in previous papers that persons suffering from hepatic disease or from toxic thyroid disease present evidence of vitamin B_1 malnutrition as revealed by the blood levels of pyruvic acid. The present paper is concerned with a study of persons suffering from renal disease, neoplastic disease and infection.

RENAL DISEASE

The kidney plays a significant role in the metabolism of vitamin B_1. Greater amounts of this vitamin are present in the liver, heart, brain, muscles and kidneys than in other tissues. The kidneys excrete a considerable quantity of the vitamin daily. This excretion continues, but to a lesser extent, even in the presence of vitamin B_1 deficiency. Finally, renal tissue is one of the tissues which can convert vitamin B_1 into cocarboxylase (Westenbrink and Goudsmit[1]). In view of these facts the question arises: In the presence of renal disease is there diminished phosphorylation and excretion of vitamin B_1 by the kidneys? Eleven patients with various forms of renal disease were studied. Blood levels of pyruvic acid were determined by the method of Lu.[2] The usual tests of renal function were carried out. The results are given in table 1. It will be noted that in this series of 11 patients only 2 presented elevated blood levels of pyruvic acid. One of them was anuric. Since this patient was receiving dextrose infusions, the increase of pyruvic acid in his blood cannot be considered significant. Despite marked azotemia and other evidences of severe failure of renal function in many of these patients the blood levels of pyruvic acid did not indicate the presence of vitamin B_1 deficiency. This may be significant in view of the fact that 5 of the 11 patients showed definite signs of malnutrition. The possibility must be considered that there is diminished excretion of thiamine hydrochloride when a diminution of renal function is present.

NEOPLASTIC DISEASE

Relatively few studies have been made of the relationship of vitamin B_1 to malignant neoplastic disease. Bischoff and Long[3] reported that vitamin B_1 did not affect the rate of tumor growth in mice although it did affect the nutritional status and somatic growth of these animals. Masayama and Yokoyama[4] found that rats with experimentally produced carcinoma of the liver had greater amounts of vitamin B_1 in the liver, spleen, heart and muscles than did normal rats. They also noted that vitamin B_1 was present in the cancer itself. These findings are in direct contrast with those of Schneider and Burger[5] who, using the thiochrome method of Jansen, found a reduction of the vitamin B_1 content of the urine and the blood serum of patients with cancer. The question arises: Is a deficiency of vitamin B_1 present in patients with malignant neoplastic disease? In order to answer this question, a series of 19 patients with various forms of cancer was studied. The data are presented in table 2. The patients were divided into three groups: group 1, patients with cancer who had neither fever nor malnutrition; group 2, patients having either fever or malnutrition; group 3, patients presenting fever and malnutrition. In group 1 were 9 patients. Their pyruvic acid levels varied from 0.5 mg. to 2.25 mg. per hundred cubic centimeters of blood; the mean was 1.31 ± 0.598 mg. This figure represents

From the Department of Surgery of the Louisiana State University School of Medicine and Charity Hospital of Louisiana at New Orleans.

1. Westenbrink, H. G. K., and Goudsmit, J.: Investigations on Aneurin and Cocarboxylase Content of Animal Tissues, Estimated by Thiochrome Method, Enzymologia **5**:307-320, 1938.

2. Lu, G. D.: Studies on Metabolism of Pyruvic Acil in Normal and Vitamin B_1-Deficient States: Rapid Specific and Sensitive Method of Estimation of Blood Pyruvate, Biochem. J. **33**:249-254 (Feb.) 1939.

3. Bischoff, F., and Long, M. L.: The Relation of the Vitamin B Complex to Tumor Growth, Am. J. Cancer **37**:54-58 (Sept.) 1939.

4. Masayama, T., and Yokoyama, T.: Ueber den Gehalt an Aneurin sowie Co-Carboxylase im Krebsgewebe und in verschiedenen Organen der Leberkrebsratte, Gann **34**:178-179 (June) 1940.

5. Schneider, E., and Burger, A.: Der Vitamin-B_1-Spiegel in Blut und Urin and seine Veränderungen bei den Hyperthyreosen und bei der Krebskachexie, Klin. Wchnschr. **17**:905-907 (June 25) 1938.

the upper limit of the normal level. The figures indicate that vitamin B_1 deficiency is not a constant finding in persons suffering from malignant neoplastic disease unaccompanied by fever or malnutrition. In group 2 were 8 patients with cancer and definite evidences of malnutrition but without fever. Their blood levels of pyruvic acid varied from 1.5 mg. to 4.25 mg. per hundred cubic centimeters, the mean level being 1.88 ± 0.897 mg. These data indicate that persons suffering from cancer accompanied by malnutrition but not by fever have vitamin B_1 malnutrition, as revealed by consistently elevated blood levels of pyruvic acid. The significance of these figures is increased when it is noted that 5 of the 8 patients were receiving supplemental thiamine hydrochloride in doses of 5 to 10 mg. three times a day. In group 3 there were only 2 patients. In both of these the blood levels of pyruvic acid were elevated, the average being 2.65 ± 0.15 mg. per hundred cubic centimeters. As might be expected, these patients showed more evidences of vitamin B_1 malnutrition than did the patients of either group 1 or group 2.

Of 19 persons suffering from malignant neoplastic disease, 14 presented vitamin B_1 malnutrition as shown by elevated blood levels of pyruvic acid. This appears to be due in part at least to associated malnutrition or fever. Vitamin B_1 malnutrition in malignant neoplastic disease may result also from deficient ingestion, digestion, absorption or utilization of vitamin B_1. The data (table 2) do exhibit a trend pointing to a relationship between the duration of the disease and the increase of pyruvic acid in the blood. This relationship does not appear in all instances.

TABLE 1.—*Blood Levels of Pyruvic Acid in Renal Disease*

Patient	Age	Diagnosis	Fever	Nutrition	Blood Urea Nitrogen, Mg. per 100 Cc.	Blood CO_2-Combining Power, Vol. per Cent	Phenolsulphonthalein Test, per Cent	Pyruvic Acid in Blood, Mg. per 100 Cc.
White ♂	42	Malignant hypertension with renal insufficiency...	0	Poor	65.0	30	55	0.95
White ♂	12	Chronic glomerulonephritis.....	0	Poor	13.4	50	75	0.6
White ♂	20	Mercury bichloride poisoning.....	0	Good	66.0	22	Anuria	1.0
White ♂	56	Chronic glomerulonephritis.....	0	Good	22.8	45	..	0.6
Negro ♂	81	Urinary retention due to prostatic carcinoma.....	0	Good	86	26	30	2.25
White ♂	15	Acute glomerulonephritis.....	+	Good	21	30	40	0.5
Negro ♀	16	Acute glomerulonephritis.....	0	Poor	31	35	30	0.8
Negro ♀	21	Acute glomerulonephritis.....	0	Poor	26	36	40	0.6
Negro ♀	27	Chronic glomerulonephritis.....	0	Good	42	35	25	1.0
Negro ♂	65	Urinary retention due to prostatic hypertrophy...	0	Good	30	44	45	1.0
Negro ♂	65	Urinary retention due to carcinoma of bladder....	+	Poor (receiving dextrose infusions)	64	22	Anuria	2.3

TABLE 2.—*Blood Levels of Pyruvic Acid in Malignant Neoplastic Disease*

Patient	Age	Diagnosis	Duration of Symptoms	Fever	Nutrition	Pyruvic Acid in Blood, Mg. per 100 Cc.
Negro ♀	45	Carcinoma of uterus.....	2 mo.	0	Poor	1.5
Negro ♀	58	Carcinoma of uterus.....	6 mo.	0	Good	1.2
White ♀	67	Carcinoma of breast, grade III.....	6 mo.	0	Poor	1.5*
Negro ♀	45	Carcinoma of breast, grade IV.....	8 mo.	+	Poor	2.5
Negro ♀	63	Carcinoma of ovary with metastases.....	2 yr.	0	Poor	4.25
White ♂	49	Hepatoma.....	6 mo.	0	Good	2.0*
Negro ♂	66	Carcinoma of rectum.....	1 yr.	0	Good	1.0
Negro ♂	67	Carcinoma of bladder.....	2 yr.	0	Poor	1.7*
White ♂	60	Sarcoma of thigh.....	3 mo.	0	Good	0.5
White ♀	32	Fibrosarcoma of thigh.....	1 yr.	0	Good	1.0
White ♂	48	Carcinoma of head of pancreas.....	18 mo.	+	Poor	2.8
Negro ♂	81	Carcinoma of prostate gland.....	3 yr.	0	Good	2.25
Negro ♂	63	Carcinoma of rectum.....	1 yr.	0	Poor	1.5
White ♂	58	Retroperitoneal sarcoma.....	1 yr.	0	Good	0.43
White ♂	12	Retroperitoneal sarcoma.....	6 mo.	0	Good	1.6
Negro ♂	52	Carcinoma of stomach.....	8 mo.	0	Poor	1.6*
White ♂	56	Carcinoma of stomach.....	1 yr.	0	Poor	1.5*
Negro ♀	53	Carcinoma of stomach.....	6 mo.	0	Poor	1.5*
Negro ♀	33	Carcinoma of stomach.....	3 mo.	0	Good	1.8

* These patients received vitamin B_1 supplements daily.

INFECTION

There have been few studies of the nutritional status with respect to vitamin B_1 of persons suffering from infection associated with fever. Tangari,[6] using Schopfer's method, noted a decrease in the vitamin B_1 content of the blood in acute experimental peritonitis. For these

6. Tangari, C.: Comportamento delle vitamine del sangue nelle peritoniti acute sperimentali, Med. sper., Arch. ital. **6**:169-178 (March) 1940.

reasons a series of 38 patients with various types of infection was investigated to determine the presence or the absence of vitamin B_1 deficiency.

TABLE 3.—*Influence of Surgical Infections on Blood Levels of Pyruvic Acid*

Patient Sex	Age	Diagnosis	Duration of Fever	White Blood Cells per Cu. Mm.	Pyruvic Acid in Blood, Mg. per 100 Cc.
♂	22	Postoperative infection...	1 day	8,600	1.6
♂	67	Extravasation of urine....	1 day	12,000	1.8
♂	45	Acute appendicitis.....	1 day	11,000	1.2
♂	45	Perineal abscess.....	1 day	18,600	0.6
♀	36	Acute pelvic inflammatory disease	1 day	10,000	1.0
♀	17	Acute pelvic inflammatory disease	1 day	15,100	1.7
♀	20	Acute pelvic inflammatory disease	1 day	10,000	1.2
♀	17	Acute appendicitis.....	1 day	11,000	1.0
♀	28	Acute pelvic inflammatory disease	2 days	8,100	1.0
♀	21	Acute pelvic inflammatory disease	2 days	8,500	1.3
♀	15	Acute appendicitis.....	2 days	16,000	1.3
♂	63	Extravasation of urine....	2 days	10,000	1.5
♀	21	Acute appendicitis.....	2 days	10,500	0.8
♂	18	Acute appendicitis.....	2 days	9,600	1.6
♂	17	Acute appendicitis.....	2 days	12,000	1.2
♂	27	Acute appendicitis.....	2 days	11,000	1.0
♂	43	Urethritis.....	2 days	6,500	0.8
♂	22	Postoperative infection...	2 days	.....	1.5
♀	51	Perirectal abscess.....	3 days	10,000	1.2
♀	22	Acute pelvic inflammatory disease	3 days	7,800	0.9
♂	18	Acute appendicitis.....	3 days	8,600	1.5
♀	26	Incomplete septic abortion	3 days	18,000	1.5
♀	29	Acute pelvic inflammatory disease	3 days	10,000	1.6
♀	24	Acute pelvic inflammatory disease	3 days	.....	1.3
♂	37	Postoperative infection...	4 days	.....	1.9
♀	16	Acute appendicitis.....	4 days	7,200	0.8
♀	64	Diabetic gangrene.....	5 days	6,800	1.7
♀	31	Acute pelvic inflammatory disease	5 days	9,000	1.45
♀	56	Diabetic gangrene.....	5 days	12,000	1.5
♀	28	Acute thrombophlebitis...	5 days	14,000	0.5
♂	45	Paronychia.....	5 days	.....	1.0
♂	13	Acute osteomyelitis.....	5 days	9,000	2.2
♀	60	Postoperative infection...	6 days	9,000	2.1
♂	14	Tetanus.....	7 days	7,000	1.2
♂	32	Closed space infection of finger	7 days	5,800	1.2
♀	52	Abscess of lung.....	18 days	12,000	1.6*
♀	32	Abscess of lung.....	36 days	8,000	1.7*
♀	20	Acute osteomyelitis of skull	18 days	10,000	1.5*

* These patients were receiving supplemental amounts of vitamin B_1.

In table 3 the patients have been grouped according to the duration of fever. Of 35 patients having fever lasting from one to seven days, 15 showed definite elevation of the blood level of pyruvic acid. This is certainly a higher incidence of vitamin B_1 deficiency than might be expected to occur among the normal hospital population. None of these patients received supplemental vitamin B_1. Three patients having various types of infection with fever lasting more than seven days all showed elevated blood levels of pyruvic acid despite the fact that all were receiving supplemental vitamin B_1 (table 3).

No statistically significant differences in blood levels of pyruvic acid appear between white and Negro patients (table 4). If our observations are confined to patients having infection with fever of a duration not exceeding seven days, it appears from the data presented that the duration of fever is not a significant factor in producing an elevation of the blood level of pyruvic acid. Thus, 26 patients with fever lasting from one to four days showed a mean value for pyruvic acid of 1.26 ± 0.337 mg. per hundred cubic centimeters, whereas 9 patients with fever of five to seven days' duration had a mean value for pyruvic acid of 1.42 ± 0.502 mg. per hundred cubic centimeters. There is no statistically significant difference between these two values (table 4). As has already been stated, 15 of 35 patients had elevated blood levels of pyruvic acid. Comparison of these levels with those of the remaining 20 patients reveals a significant difference since P is < 0.01 (table 4). The factors leading to abnormally high levels of pyruvic acid in the presence of infection with fever of short duration are not clear. There does not appear to be any correlation between such levels and the degree of constitutional reaction to infection as exemplified by the leukocyte count (table 3). The extent of tissue involved in the inflammatory process may be a factor influencing the level of pyruvic acid. Elevated levels appear to occur more frequently in association with postoperative febrile disturbances and infections (table 3). Certain of these patients might have been in a state of vitamin B_1 malnutrition before the onset of infection. Under such circumstances the pyruvic acid levels might become elevated more readily. This could explain the occurrence of abnormally high blood levels of

TABLE 4.—*Effect of Surgical Infections on Blood Levels of Pyruvic Acid*

Groups	Number of Patients	Pyruvic Acid in Blood, Mg. per 100 Cc., Mean	Difference Between Means	t	P*
White patients with fever lasting 1 to 7 days.....	12	1.27 ± 0.387			
Negro patients with fever lasting 1 to 7 days.....	23	1.31 ± 0.387	0.04	0.277	>0.7
Patients with fever lasting 1 to 7 days—group a.....	20	1.01 ± 0.23			
Patients with fever lasting 1 to 7 days—group b.....	15	1.67 ± 0.222	0.66	5.0	<0.01
Patients with fever lasting 1 to 4 days.....	26	1.26 ± 0.337			
Patients with fever lasting 5 to 7 days.....	9	1.42 ± 0.502	0.16	0.88	>0.3

* P is derived from Fisher's table of t (Fisher, R. A.: Statistical Methods for Research Workers, London, Oliver & Boyd, Ltd., 1938). In comparing two groups, P is significant if it is <0.05.

pyruvic acid in 3 of 8 patients after fever of only one day's duration (table 3).

CONCLUSIONS AND SUMMARY

The blood levels of pyruvic acid have been studied in three groups of patients. In a series of 11 persons suffering from various forms of renal disease the pyruvic acid in the blood was not increased despite the fact that azotemia was present in many of these patients. One patient with anuria and uremia showed a normal blood level of pyruvic acid. In only 2 patients was the blood level of pyruvic acid elevated. One of these patients had fever, to which the elevation of blood pyruvic acid could be attributed. The second patient was receiving dextrose infusions, and this could explain the elevation of the pyruvic acid in his blood. These facts suggest that renal disease even when associated with severe failure of renal function is not accompanied by an increase of the pyruvic acid in the blood. The possibility exists that patients with severe renal disease are protected to some extent against the onset of vitamin B_1 deficiency by diminution of the excretion of the vitamins in the urine. A second group of patients was studied. This consisted of 19 persons suffering from malignant neoplastic disease. It was found that in such patients vitamin B_1 malnutrition as shown by an elevation of the blood level of pyruvic acid might occur even in the absence of fever and obvious malnutrition. The levels were more likely to be elevated, however, when fever and malnutrition also were present.

The third group studied consisted of 38 persons suffering from various types of infection associated with elevation of the body temperature. It was found that 18 of these patients had vitamin B_1 malnutrition as revealed by an increase in the blood levels of pyruvic acid.

TWO STAGE OPERATION FOR CARCINOMA OF TRANSVERSE COLON PRODUCING DUODENOCOLIC FISTULA

REPORT OF TWO CASES

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Numerous articles demonstrating the feasibility of the surgical removal of the duodenum and the head of the pancreas for carcinoma involving one or both of these organs have appeared in the surgical literature since Whipple [1] reported the successful extirpation of the head of the pancreas in 1938. Colectomy of the right side in either one or two stages, for malignant lesions involving the cecum, ascending colon or hepatic flexure, is a well recognized surgical procedure which carries a relatively low mortality rate.

The cases reported in this communication are of interest because they present instances of primary carcinoma of the proximal portion of the transverse colon which had eroded the second portion of the duodenum, producing a large fistulous opening between the two lumens of the bowel. Removal required colectomy of the right side and in addition necessitated the carrying out of the Whipple type of operation for carcinoma of the pancreas. This was successfully performed in both cases. The operative procedure was done in two stages because the patients were in a serious state of malnutrition from the malignant condition and their inability to assimilate food due to the duodenocolic fistulas. In addition the danger of severe postoperative infection would have been much greater in a one stage operation, since all the lumens of the bowel including the stomach and duodenum contained highly infective fecal material because of the communication between the duodenum and the colon. The first stage of the operation consisted in by-passing the fistula by transecting the stomach and terminal ileum and performing a gastrojejunostomy and an ileotransverse colostomy. The second stage consisted of the removal of the primal growth and the involved organs after the patient's nutritional state had been improved.

From the Surgical Service of the Massachusetts General Hospital.

1. Whipple, A. O.: Surgical Treatment of Carcinoma of the Ampullary Region and Head of the Pancreas, Am. J. Surg. **40**:260 (April) 1938.

REPORT OF CASES

CASE 1.—*History.*—P. B., a 59 year old Italian man, a worker in a pottery shop, was admitted to the Massachusetts General Hospital Nov. 13, 1941. The chief complaint was vomiting and watery diarrhea of five months' duration, worse in the last week. He was well until six months before admission except for occasional attacks of indigestion. At this time mild epigastric distress developed, with gas and belching occurring a few hours after eating. He vomited several times a week. The vomitus consisted largely of bile, rarely of food. Prior to one year before admission his bowels moved two to four times weekly. Approximately one year before he began having movements daily and three months before admission diarrhea commenced, with five to fifteen movements each day. During the past few weeks on numerous occasions he had noted the passage of undigested food in his stools, eaten only fifteen minutes before. One week before his admission daily nausea and vomiting developed. He had lost 20 pounds (9.1 Kg.) in weight, from 185 to 165 pounds (83.9 to 74.8 Kg.), during the past three months. He had dyspnea on exertion of one year's duration. The remainder of his history was irrelevant.

Examination.—Physical examination showed a well developed, moderately well nourished middle-aged man with signs of recent loss of weight. His skin was dry, with some loss of elasticity. The pupils were equal and reacted to light and in accommodation. He had a number of carious teeth. His lungs were clear to auscultation and percussion. The heart was of normal size, the sounds were of good quality and the blood pressure was 120 systolic and 70 diastolic. The abdomen was symmetric and soft. In the right upper quadrant there was a large firm mass which was palpable below the edge of the liver. It felt about 5 cm. in diameter. It did not move with respiration. Rectal examination gave normal results except for anal spasm and an enlarged soft prostate. His weight on admission was 144 pounds (65.3 Kg.). Examination of the blood showed 3,500,000 red blood cells, 6.2 Gm. of hemoglobin, 24 per cent of hematocrit, 11,100 white blood cells and a normal blood smear except for hypochromia. The urine had a specific gravity of 1.020 and gave a negative reaction for albumin, sugar and bile. Blood chemistry determinations showed serum protein 5.8 Gm. and nonprotein nitrogen 42 mg. per hundred cubic centimeters, blood chlorides of 106.2 milliequivalents per liter, a vitamin C level of 0.2 mg. per hundred cubic centimeters and a normal reaction to the van den Bergh test. The stool gave a positive reaction to the guaiac test. A gastric analysis showed some brown-yellow fecal-smelling fluid with no free hydrochloric acid and a negative reaction to the guaiac test. Roentgen examination of the gastrointestinal tract by Dr. R. Schatzki showed a normal esophagus and stomach.

The duodenal cap was wide. The second and third portions of the duodenum appeared normal but were displaced medialward. Most of the barium after entering the duodenum passed into an irregular cavity with finger-like extensions in the right upper quadrant, and then entered the colon. The findings indicated a duodenocolic fistula and a large mass in the right upper quadrant. The mass had the appearance of a large carcinoma of the hepatic flexure. Examination after a barium enema showed normal filling to the hepatic flexure, where a filling defect of 7 cm. was noted. A small amount of barium passed into the first portion of the duodenum. The descending portion of the duodenum appeared uninvolved but there appeared to be some infiltration of the ascending portion of the colon. The findings confirmed the previous roentgenogram in that they showed a large tumor of the hepatic flexure with a fistula into the proximal part of the duodenum.

Operations and Course.—Following his admission two blood transfusions of 500 cc. each were given.

On Nov. 22, 1941 a peritoneoscopy was done under local anesthesia by Dr. E. B. Benedict. The liver throughout the anterior surface of both lobes appeared of normal color, smooth in outline with a sharp edge. There was no evidence of metastatic disease in the liver or peritoneum. The fundus of the gallbladder appeared normal. The mass in the right upper quadrant was entirely covered by omentum, so that it was impossible to tell regarding the fixation of it.

On November 25, twelve days after admission to the hospital, an operation was performed. The anesthesia was induced with nitrous oxide and oxygen and continued with ether administered through an endotracheal cannula. The abdomen was opened through a left paramedian incision, the rectus muscle being retracted lateralward. The tumor was found to be fairly freely movable, although intimately associated with the duodenum. It seemed unwise to attempt a complete excision at this operation. After it had been determined that there were no metastases in the liver or in the pelvis and that the gallbladder was free and not involved, the stomach was transected at the junction of the middle and lower thirds. The distal end was infolded with two rows of sutures. A posterior Polya anastomosis between the jejunum and the proximal end of the stomach was performed. The transverse mesocolon, through which the jejunum was brought up, was sutured to the wall of the stomach proximal to the anastomosis. The ileum was then transected about 8 inches (20.32 cm.) from the ileocecal valve. The distal end of this was infolded with two rows of sutures and dropped back into the peritoneal cavity. An end-to-side anastomosis was performed between the proximal end of the ileum and the transverse colon 6 inches (15.24 cm.) distal to the growth. The gastrojejunostomy and the ileocolostomy were carried out according to the Allen[2] modification of the Parker-Kerr aseptic type of intestinal anastomosis. The abdominal wound was then closed in layers without drainage. The operation required two hours and a half, and during this time the patient received intravenously 1,000 cc. of citrated blood.

The patient made a satisfactory convalescence except for the complication that large amounts of thin fecal material drained from an inlying nasal catheter which had been placed in his stomach. On the fourth postoperative day this amounted to as much as 4,000 cc. A positive fluid balance was maintained despite this by the use of fluids injected intravenously. He received a transfusion of 500 cc. of blood on the third, fifth and eleventh postoperative days. The drainage from his stomach gradually decreased, and on the tenth postoperative day he had a positive fluid balance; so the inlying nasal catheter was removed.

On December 4, the ninth postoperative day, it was noted that his right leg had become edematous and tender in the calf, and a diagnosis of deep venous thrombosis was made. Accordingly, under local anesthesia the right femoral vein was exposed in the groin. A large clot was removed from it. The vein was ligated and divided between the ligatures. On the following day, the tenth postoperative day, venous thrombosis of the left calf was noted. With the patient under local anesthesia with procaine hydrochloride the superficial femoral vein of this extremity was interrupted in the groin. On December 11, fourteen days after his first operation, a second abdominal operation was performed. The anesthesia was induced with nitrous oxide and oxygen and continued with ether administered through an endotracheal cannula. The abdomen was opened through a right paramedian incision, the rectus muscle being retracted lateralward. An additional transverse abdominal incision was made, extending lateralward out into the right flank, making a T-shaped incision. The cecum and ascending colon with the terminal ileum attached were first freed up

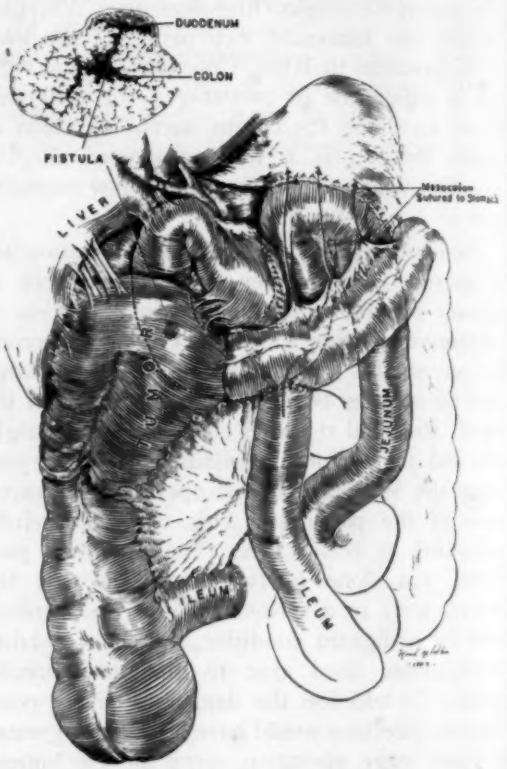

Fig. 1.—Operative sketch showing the first stage procedure to by-pass the duodenocolic fistula in case 1. The stomach and terminal part of the ileum have been transected. A posterior gastrojejunostomy and an ileotransverse colostomy distal to the carcinoma have been performed. The distal ends of the stomach and ileum have been closed. The inset shows a cross section through the duodenum and the colon at the site of the fistula.

2. Allen, A. W.: Aseptic Intestinal Anastomosis Applicable to Gastrojejunocolic Fistula, Surgery **1**:338 (March) 1938.

as for colectomy of the right side. A large amount of inflammatory and carcinomatous tissue was encountered in the right gutter. It was possible to get entirely around this, although it was necessary to sacrifice the right ureter in order to do it. The dissection was continued upward until the duodenum was reached. It was freed from the inferior vena cava posteriorly, which gave off a few small tributaries to it. The distal half of the stomach, the duodenum down to the point where it passes beneath the superior mesenteric vessels, the head of the pancreas, the terminal part of the ileum, the appendix, the cecum, ascending colon and the right portion of the transverse colon with the tumor were removed en masse. The common bile duct was divided as it entered the second portion of the duodenum. The pancreas was resected at the point where the portal vein crosses beneath it. The right colic and ileocolic arteries and veins were ligated at their origins from the superior mesenteric artery and vein. The transverse colon was divided

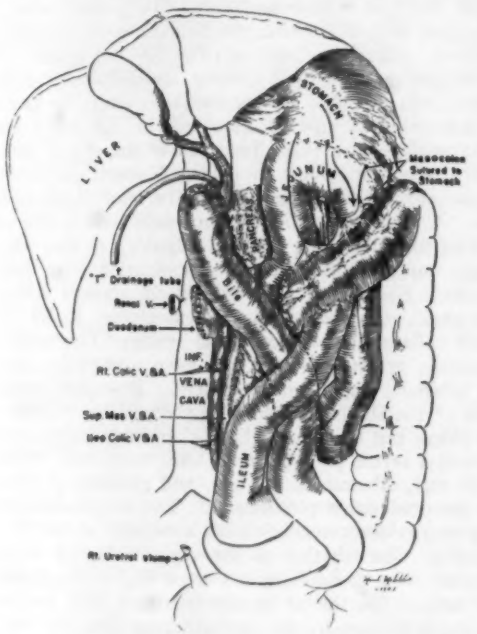

Fig. 2.—Operative sketch showing the complete second stage procedure after removal of the carcinoma and the organs involved in case 1. In this patient the right kidney also was removed. The choledochojejunostomy over a T tube and the jejunojejunostomy after the principle of Roux are shown.

just proximal to the ileotransverse colostomy. The distal end of the third portion of the duodenum and the colon were infolded with two layers of sutures. The flow of bile into the intestine was reestablished by the Roux type of anastomosis as recommended by Whipple.[1] The jejunum was divided about 12 inches (30.48 cm.) distal to the gastrojejunostomy. A choledochojejunostomy was performed between the distal end of the jejunum and the end of the common bile duct. This was made over a T tube to give the bile a vent and also to prevent temporary closure of the anastomosis from edema. A side-to-side jejunojejunostomy was made between the proximal jejunal segment, after the end of it was closed, and the jejunum distal to the choledochojejunostomy. Since the right ureter had to be sacrificed, the right kidney was then removed, the renal artery and vein being doubly ligated. The raw area in the right side of the abdomen was peritonealized. The main pancreatic duct was isolated and ligated with a cotton ligature. The cut end of the pancreas was closed with interrupted sutures of cotton. A few glands were noted in the region of the portal vein at its junction with the superior mesenteric vein. This was the only evidence that there might be metastatic disease. The T tube in the common duct was brought out through a small stab wound in the right side of the abdomen. Two cigaret wicks were placed in the region of the sutured end of the pancreas and were separated from the common duct tube by a small amount of gastrohepatic omentum. The abdomen was closed in layers after 4 Gm. of sulfanilamide was deposited in the right side. There was no free omentum to use to wall off any of the intestines because it had been involved in the tumor and had to be resected.

The operation lasted five hours and thirty-five minutes, and the patient received two transfusions of citrated blood of 500 cc. each. The blood pressure was not discernible at the end of the operation, but his pulse rate was in the neighborhood of 130. Despite the magnitude of the operation and the long time it required to complete it, the patient had a fairly good convalescence. He was placed in an oxygen tent; sulfadiazine was given intravenously. This was continued for three days postoperatively, 4 Gm. being given each day. Pancreatic secretion commenced to drain on the fifth postoperative day. By means of suction in the wound this was collected, and it amounted to 500 or 600 cc. each day. The fistula gradually stopped draining sixteen days after the operation. On Jan. 6, 1942, twenty-six days after the operation, a considerable amount of pus drained through the lateral end of the transverse incision. After this he improved. An injection of hippuran through the common duct tube showed prompt emptying of the contrast material into the jejunum. It was noted about this time that he had definite avitaminosis with a smooth red atrophic tongue. He was given vitamin B parenterally. On January 28, his weight was 125 pounds (56.7 Kg.). His serum protein was 4.5 Gm. and his nonprotein nitrogen 15 mg. per hundred cubic centimeters. He had considerable difficulty in eating, but gradually improved. His wounds finally healed, and he was discharged from the hospital on February 3, fifty-four days after his last operation. He was sent to a nursing home, where he stayed until March 12, at which time it was reported that his appetite was very good, that he had gained weight and that he was able to be up and about.

Pathologic Examination.—The pathologist's report was as follows: Gross Examination: A kidney weighed 191 Gm. and measured 11.5 x 6.5 x 4 cm. The capsule was thin and stripped readily, to reveal a smooth, brownish purple surface. The calices were not dilated; the pelvis was smooth and shiny. The intestinal mass measured 33 x 17 x 18.5 cm. It consisted of a central tumor measuring 15 x 9.5 x 18 cm. and located 8 cm. above the tip of the cecum. The mass was located primarily within the colon, which was almost completely filled. The tumor was a soft, fungating, papillary reddish purple mass, the center of which was grossly necrotic. The remaining mucosa of the colon was normal in appearance. Attached to the cecum were a normal-appearing appendix measuring 6 x 0.8 cm. and a normal-appearing section of the ileum measuring 14 cm., the end of which had been previously sutured. The tumor had extended through the wall of the colon to invade the wall of the duodenum,

which was affixed to the upper outer aspect of the colon. The tumor extended into the duodenum over an area measuring 10 x 5 cm. and protruded into the lumen for a distance of about 1.5 cm. There was a fistulous communication through the necrotic tumor between these two structures. The tumor apparently had also grown into the omentum, where it was found as firm, gray-white strands of tissue infiltrating the soft, fatty tissue. The stomach portion measured 11 x 9 cm. and showed soft thick folds and had been previously sutured at its proximal end. The tissues examined consisted of colon, ileum, kidney, stomach, appendix and duodenum. There was a portion of the pancreas on the posterior aspect of the tumor mass which was intimately adherent to it and the duodenum and partially infiltrated with the tumor tissue.

The diagnosis was: adenocarcinoma, grade 2, of the transverse colon with perforation into the duodenum; normal kidney; normal appendix.

The patient reported to the hospital on August 17, stating that he had felt well until three weeks previously when he began to have indigestion immediately after eating, with pain in the epigastrium and occasional vomiting and five to six stools a day. These consisted mostly of undigested food. He was readmitted to the hospital for study and a roentgenogram of the gastrointestinal tract was made. This showed a subtotal gastrectomy with prompt emptying of the barium into the anastomosed jejunum. The upper part of the jejunum was slightly dilated and no barium passed it during forty-five minutes. The findings were those of a partial obstruction in the upper part of the small intestine. Blood chemistry studies at this time showed a nonprotein nitrogen of 20 mg. and serum protein of 4.8 Gm. per hundred cubic centimeters and blood chlorides of 103.2 milliequivalents per liter. An enema of barium sulfate was given at this time, and it showed that the barium passed from the rectum to the midtransverse colon. Just proximal to the splenic flexure the barium was observed to go into the small intestine at the site of the anastomosis. No evidence of recurrent disease was observed. The red blood count was 4,300,000, the white blood count 8,200 and the hemoglobin content 80 per cent. He was discharged from the hospital five days after his admission on August 22. He was given instructions in the regulation of his dietary regimen to reduce the amount of nausea, vomiting and diarrhea and to correct his vitamin deficiency. His weight on this admission was 141 pounds (64 Kg.) a gain of 16 pounds (7.3 Kg.) since his discharge from the hospital.

One month later he died at another hospital, where a diagnosis of heart failure was made. No autopsy was performed, so it is impossible to determine if metastases had developed which might have played a role in his death. He had survived ten months since the tumor had been resected.

CASE 2.—*History.*—H. W. R., a 45 year old man, American, a brakeman, was admitted to the Massachusetts General Hospital on Jan. 4, 1943. The chief complaint was shifting pain in the epigastrium and in both lower quadrants of the abdomen for the past seven months. The pain was described as constant, dull and aching, with transient sharp epigastric exacerbations which sometimes were referred to the back. His appetite was poor and occasionally he felt nauseated and vomited. There was no relation between the pain and his meals; there was no change in bowel habits except for a slight watery brown diarrhea in the past week. He had gradually lost strength and in the past four months had lost 23 pounds (10.4 Kg.). In July 1938 it was found that he had a positive reaction to the Wassermann and Hinton tests at the Peter Bent Brigham Hospital. He then received treatment for syphilis both at that hospital and at the Massachusetts General Hospital. This type of therapy resulted in attacks of dermatitis, but it was possible to continue antisyphilitic treatment by careful regulation of the dosage. In March 1941 he complained of precordial pain, radiating down his left arm, and a diagnosis of a recent anterior myocardial infarction was made by electrocardiogram. This condition responded well to rest and regulation of his activities.

Examination.—Physical examination showed a well developed, fairly well nourished, pale, sallow man 45 years old, who appeared chronically ill and showed evidence of recent loss of weight. His skin was pale and dry, with hyperkeratotic lesions and scaling of the skin of the forearm. There was a slight yellowish tinge to the scleras of his eyes. The right pupil was slightly larger than the left. Both pupils reacted to light and in accommodation. His heart was not enlarged to percussion; the sounds were distant and muffled. The rate and rhythm were regular. The blood pressure was 112 systolic and 60 diastolic. The lungs were clear to percussion and auscultation. Abdominal examination revealed in the right upper quadrant a large mass just below the costal margin, which was felt to be an enlarged liver. It extended down into the right flank below the level of the umbilicus. It descended slightly on respiration. The edge of this mass was not readily palpable; it was slightly tender on pressure. Rectal examination gave normal results. Examination of the blood showed 4,400,000 red blood cells, 12.5 Gm. of hemoglobin, 15,300 white blood cells and a normal blood smear. The urine had a specific gravity of 1.016 and gave a negative reaction for albumin, sugar and sediment. Repeated examinations of the stools showed strongly positive reactions to the guaiac test for blood. Blood chemistry determinations showed a serum protein of 5.7 Gm., nonprotein nitrogen of 26 mg., albumin of 2.9 Gm. and globulin of 2.8 Gm. per hundred cubic centimeters. The prothrombin time was twenty-three seconds with a normal of twenty-two seconds. The reaction to the van den Bergh test was normal. The blood chlorides were 98.3 milliequivalents per liter. The blood hematocrit was 38.8 per cent. Roentgen studies by Dr. R. Schatzki after the patient was given dye revealed a normal gallbladder. An intravenous pyelogram revealed normal kidneys. A series of gastrointestinal roentgenograms after barium was given by mouth showed a scarred deformity of the duodenal cap. The junction of the second and third portions of the duodenum as well as the lower third was poorly filled throughout the examination. The third portion of the duodenum appeared to be irregular and was probably ulcerated. The examination was suggestive of an ulcerating tumor of the third portion of the duodenum. The esophagus and stomach were normal. A barium enema flowed easily up to the junction of the hepatic flexure with the transverse colon. At this point the barium column first met an obstruction and then filled an irregular pocket; then it entered the duodenum at the junction of the second and third parts. Later films showed the stomach and jejunum partially outlined by barium.

A diagnosis was made of a duodenocolic fistula with marked destruction of the wall of the colon, probably secondary to carcinoma of the colon.

Operations and Course.—The patient's condition did not improve during these studies. On January 23, his red blood count had dropped to 2,000,000. He received

a transfusion of 500 cc. of citrated blood on January 23 and 24. On the evening of January 24, severe pain suddenly developed in the right upper quadrant of the abdomen, with spasm and tenderness in the region of the mass. His temperature had risen to 103 F. The development of these signs and symptoms indicated beginning peritonitis, possibly from perforation of the carcinomatous growth.

An emergency laparotomy was performed on January 24, at 10 o'clock in the evening. The anesthesia

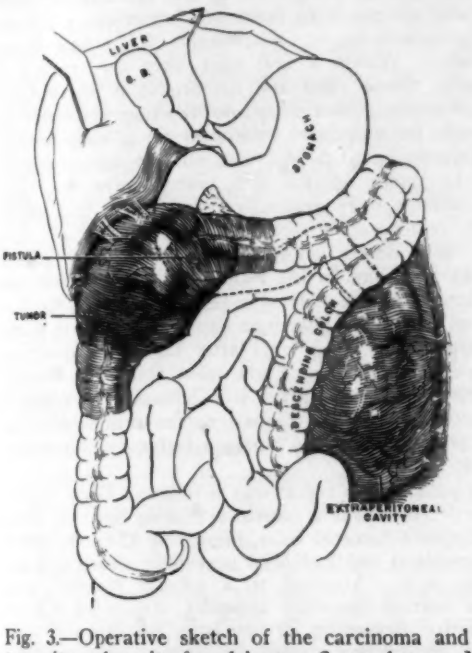

Fig. 3.—Operative sketch of the carcinoma and the extraperitoneal cavity found in case 2 are shown. Note the descending colon lies medial to the latter.

was induced by nitrous oxide and oxygen and continued with ether administered through an endotracheal cannula. The abdomen was opened through a left paramedian incision, the rectus muscle being retracted lateralward. The lesion in the right side of the colon was visualized. It was covered with fresh fibrin but there was no active peritonitis. It was ascertained that there were no metastatic nodules in the liver. The large tumor mass was slightly movable, and it was considered to be an operable growth. The stomach was transected through its midportion. An anterior gastrojejunostomy was performed with the distal loop attached to the greater curvature. A congenital anomaly was encountered when the upper part of the jejunum was searched for. The ligament of Treitz could not be found, and then it was ascertained that the upper loops of jejunum lay in a separate peritoneal cavity which was lateral to the attachment of the mesentery of the descending colon (fig. 3). This sac which contained the upper several feet of jejunum, was opened anteriorly and the ligament of Treitz localized. The aperture in the sac was made as large as possible to prevent strangulation of the bowel. The gastrojejunostomy was performed approximately 12 inches (30.48 cm.) distal to the ligament of Treitz. An antecolic type of anastomosis was performed. Because of the displacement of the descending colon medialward by the congenital anomaly, it was necessary to bring the loop of jejunum over both the transverse colon and the proximal portion of the descending colon (fig. 4). The terminal ileum was next divided about 6 inches (15 cm.) proximal to the ileocecal valve and an end-to-side aseptic type of anastomosis was performed between the proximal end of the ileum and the transverse colon about 8 inches (20 cm.) distal to the growth. The distal end of the ileum was closed with two rows of sutures and dropped back into the peritoneal cavity. Both the gastrojejunostomy and the ileocolostomy were carried out according to the Allen [2] modification of the Parker-Kerr technic. The abdominal wound was then closed in layers without drainage. The patient received one transfusion of 500 cc. of citrated blood during the operation and another one immediately afterward. Because of danger of peritonitis administration of sulfadiazine intravenously was begun.

Following this operation the patient did fairly well but large amounts of thin brownish fecal-smelling fluid drained from a Levine tube placed in his stomach. Despite keeping this tube on constant suction he retched and vomited considerably and on January 31, seven days after his operation, dehiscence of the wound developed. He was taken to the operating room, and under spinal anesthesia the wound was sutured with silver wire through all layers of the abdominal wall. At this operation it was ascertained that the gastrojejunostomy appeared in excellent condition and was patent. The distal loop of the jejunum was dilated about 8 inches distal to the anastomosis, but there was no obvious mechanical obstruction. It was decided at this time to do a supplementary jejunostomy for feeding purposes since the gastrojejunostomy was not functioning, as recommended by Allen.[3] This was done by suturing a rubber catheter into the jejunum with

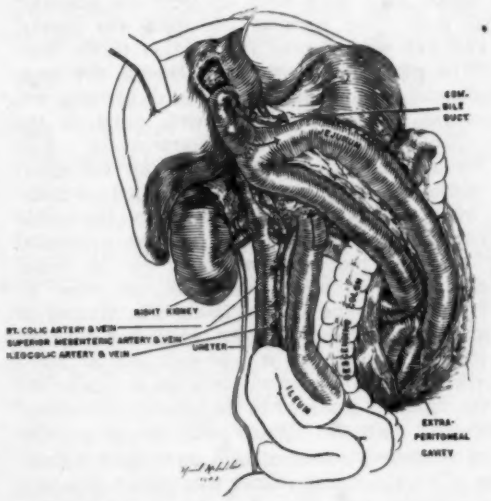

Fig. 4.—Operative sketch showing the completed second stage procedure after removal of the carcinoma and the organs involved in case 2. The cholecystojejunostomy proximal to the gastrojejunostomy is shown. Note the latter is an antecolic type over both transverse and descending colons which was necessary due to the congenital anomaly of an extraperitoneal cavity.

two purse-string sutures, bringing the tube out through a stab wound in the left hypochondrium.

3. Allen, A. W., and Welch, C. E.: Jejunostomy for the Relief of Malfunctioning Gastro-Enterostomy Stoma, Surgery **9**:163 (Feb.) 1941.

The most satisfactory jejunostomy feeding was equal parts of milk and lime water. He was given 1,000 cc. of this mixture each day, and to it was added 100 Gm. of amigen [4] as a 10 per cent solution and vitamins B, C and K. Large amounts of material continued to drain from his stomach tube. This was strained and also run into his jejunostomy tube by a continuous drip. The gastrojejunostomy gradually began to function, and it was possible to feed him small amounts of liquid food by mouth. By means of this regimen it was possible to keep his blood chemistry practically normal. On February 12, his nonprotein nitrogen was 20 mg. and his serum protein 6.3 Gm. per hundred cubic centimeters, and his blood chlorides 93.8 milliequivalents per liter.

On February 4, eleven days after his first operation and four days after the suture of his wound, pain developed in the chest and a roentgenogram showed a shadow at the base of the right lung consistent with a pulmonary infarct. For this reason and because of slight tenderness in the calves of his legs he was taken to the operating room again and under local anesthesia with procaine hydrochloride both superficial femoral veins were interrupted in the groin just distal to the profunda branch to prevent further embolism.

After about two weeks of the jejunostomy feedings it was decided that he was in as good a condition as possible and on February 20, twenty-seven days after his first laparotomy, the tumor mass was removed through a transverse abdominal incision. Endotracheal ether anesthesia was used. Numerous peritoneal adhesions were encountered, involving the small bowel. These had developed since the resuture of the wound. The terminal ileum, appendix, cecum and ascending colon were first freed up as for colectomy on the right side. Then the distal portion of the stomach, the duodenum and the tumor mass were freed up from the posterior abdominal wall. The common bile duct was normal in size and was severed near its junction to the duodenum. The pancreas was resected through the neck. The duodenum was divided in its third portion, and the transverse colon was divided well distal to the carcinoma but proximal to the ileotransverse colostomy. An attempt was made to free up the distal portion of the duodenum to bring it around to anastomose with the gallbladder. This was impossible because of the numerous adhesions and the congenital anomaly noted at the first operation; so the distal end of the duodenum was closed with two rows of sutures. The distal end of the colon was treated in a similar manner. The common bile duct was of normal size or smaller; so it was tied and a cholecystojejunostomy was performed between the gallbladder and the jejunum proximal to the gastrojejunostomy. The pancreatic duct was ligated with cotton and the cut end of the pancreas sutured with interrupted sutures of cotton. The abdominal wound was closed in layers and two cigaret wicks were brought out through a stab wound in the right flank. Four grams of sulfanilamide powder were placed in the raw area from which the tumor had been removed. The operation lasted four hours and forty-five minutes. The patient received three blood transfusions of 500 cc. each during the operation and immediately after the operation received an additional 1,000 cc. of blood, totaling in all 2,500 cc. Despite the extensive dissection and the long operation he stood the procedure very well. He was placed in an oxygen tent for two days. Administration of sulfadiazine intravenously was commenced the day of operation. He was given another blood transfusion on February 22, the second postoperative day, and one on February 23, of 500 cc. each.

His convalescence was complicated the first five postoperative days by jaundice. His reaction to the van den Bergh test rose to 20.2 mg. of bilirubin on the third postoperative day, but it returned to normal on the ninth postoperative day. It was felt that the jaundice was secondary to intensive chemotherapy and the intraperitoneal use of sulfanilamide at the time of the operation. Within a few days after the removal of the large tumor mass and the organs it involved, his gastrointestinal tract began to function normally and although feedings were continued for a time through the jejunostomy tube he was able to taken nourishment by mouth on the fifth postoperative day. The oral feedings were gradually decreased so that on the eighth postoperative day he was taking a soft solid diet. A moderate amount of pancreatic juice drained through the sinus in his right flank, but it never was a serious problem. He was discharged from the hospital on March 19, fifty-four days after his first operation and twenty-seven days after his second operation. He was able to take a six meal bland diet without discomfort. He was given iron, vitamin B concentrate and vitamin C and a request to the ration board for more points in order to obtain a better diet for regaining his weight.

The pathologist's report was as follows: Gross Examination: There was a normal-appearing terminal ileum, including the ileocecal valve, measuring 12 cm. in length. The proximal end had been previously closed and was healing well. Attached to a grossly normal cecum was a normal-appearing appendix, measuring 5.5 cm. in length. Beginning 20 cm. from the ileocecal valve was a constriction caused by a gray-white granular ulcerating mass 8 cm. in length with raised edges not covered with mucosa. Beyond the tumor was 6 cm. of normal transverse colon ending as an infolded stump. The mass had eroded posteriorly and superiorly through the wall of the colon, invading and ulcerating into the anteroinferior wall of the duodenum, forming a fistula 4 cm. in diameter. A portion of the stomach measuring 8 cm. along the lesser curvature and 12 cm. along the greater curvature and having the proximal end closed and fairly well healed was attached to 4 cm. of apparently normal duodenum before it entered the mass. Distal to the fistula there was 6 cm. of normal duodenum. Entering the duodenum in the uninvolved portion beneath the mass was a common bile duct which was normal and measured 4 cm. Beneath the duct and beneath the mass was the head of the pancreas measuring 4 by 4 by 3 cm. It was normal. Many enlarged lymph nodes varying in size from 0.5 to 3 cm. contained firm gray-white tumor-like tissue. Submitted separately were several soft gray-red lymph nodes, each measuring 1 cm. in diameter.

The diagnosis was: carcinoma of the transverse colon with invasion of the duodenum, duodenocolic fistula, chronic gastritis and normal pancreas.

The microscopic examination showed that the regional lymph nodes were negative and the tumor was undifferentiated.

The patient was seen on October 20, eight months after his tumor had been removed. He was able to work but was having some abdominal discomfort and cramps. Examination of his abdomen revealed a firm, movable mass in the right lower quadrant which was thought to represent metastatic disease.

4. A sterilized aqueous, nonpyrogenic 10 per cent solution of an enzymic hydrolysate of purified casein and pork pancreas. Hydrogen-ion concentration is adjusted to p_H 6.5 (Mead Johnson & Company).

COMMENT

Carcinoma of the colon is a relatively common disease. If it is located in the right half of the transverse colon it may erode into the duodenum to produce a duodenocolic fistula. An adequate operation to cure malignant disease should include the removal of the primary tumor, any organ involved by it, and the regional lymph nodes. In cases similar to the two presented, it is necessary therefore to plan a "block" type of resection which will remove the distal half of the stomach, the duodenum, the head of the pancreas, the terminal ileum, the cecum, the ascending colon and the right half of the transverse colon. Patients with lesions of this type are in a poor nutritional state because of the malignant disease and their inability to assimilate nourishment, the result of the high intestinal fistula.

An operation of the magnitude outlined requires multiple anastomoses to reestablish gastrointestinal and biliary continuity and in addition an extensive dissection in the retroperitoneal area. If it is attempted as a one stage procedure with the patient in a poor nutritional state, there is grave danger of uncontrollable surgical shock. In addition sepsis may be a serious complication since all the lumens of the bowel, which it is necessary to cut across to do the resection and utilize in the various anastomoses, namely, the stomach, duodenum, jejunum and colon, contain highly infective fecal material, the result of the duodenocolic fistula. For these reasons the operative procedure in both cases was divided into two stages.

The first stage consisted in by-passing the duodenocolic fistula in order to improve the patient's condition and to free the upper intestinal tract of fecal material (fig. 1). This was done by transecting the stomach and the ileum and then performing a gastrojejunostomy and an end-to-side ileotransverse colostomy as far distal to the growth as possible. The stomach was divided at the junction of its middle and lower thirds and the ileum 6 inches (15.24 cm.) proximal to the ileocecal valve. The distal end of the stomach and ileum were closed and dropped back into the peritoneal cavity. In one case a retrocolic gastrojejunostomy was performed, while in the other an antecolic gastrojejunostomy was necessary because of a congenital anomaly of the peritoneal cavity involving the upper part of the jejunum (fig. 3). The former is preferable since the ileotransverse colostomy and the jejunal anastomosis to the biliary tract can be more readily accomplished if the jejunum does not cross anterior to the transverse colon.

Large amounts of liquid fecal material drained from the stomach in both cases following the first stage operation. This apparently resulted from a reflux of ileal contents from the ileotransverse colostomy into the transverse colon through the fistula into the duodenum and then into the stomach through the gastrojejunostomy. This complication hindered the preparation of the patients for the second stage procedure. In the first case the fecal gastric drainage stopped after a week, but in the second one it persisted for a longer period. It could have been avoided if the transverse colon had been divided proximal to the ileotransverse colostomy at the first stage operation. It was intentionally omitted, however, because it was feared that material might collect under tension in the right part of the colon, since the only opening in it would have been the fistulous tract into the duodenum. In view of the postoperative course in these 2 patients, it seems that division of the transverse colon proximal to the ileotransverse colostomy could be carried out safely with benefit at the first operation in patients with similar lesions, since the duodenocolic fistula will give an adequate vent to the closed off part of the colon on the right side.

The gastrojejunostomy in the second case did not function properly after the first stage operation. The cause of this was not determined. It may have resulted from some reflex mechanism secondary to the primary growth, since after the second stage it functioned properly. In order to prepare this patient for the second operation it was necessary to perform a jejunostomy for feeding purposes. The value of this simple procedure cannot be overemphasized under these circumstances, as Allen [3] has pointed out. There is no question that if it had not been done in this patient he would never have been in a condition to withstand the radical second stage operation. Equal parts of milk and lime water proved to be the best jejunostomy formula. To each liter of this mixture were added 100 Gm. of amigen as a 10 per cent solution and vitamins B, C and K. In addition the drainage from the stomach was filtered and run into the jejunostomy opening by a Murphy drip. He was kept on this regimen for eighteen days prior to the second stage operation. The most striking result obtained by this therapy was the increase of his serum protein level from 4 to 6.3 per cent and in addition normal chloride and nonprotein nitrogen levels were maintained in the blood.

The second stage was performed in the first patient fourteen days after the first stage and in the second patient after eighteen days. The operative procedure in both cases necessitated

the removal of the distal portion of the stomach, the duodenum, the head of the pancreas, the terminal ileum, the cecum, the ascending colon and half of the transverse colon with the tumor mass (figs. 2 and 4). In the first case nephrectomy was performed on the right side in addition, since the right ureter had to be sacrificed because of its apparent involvement in the tumor mass.

The terminal part of the ileum, the cecum and ascending colon were dissected free as in a colectomy of the right portion. A radical resection of the ileocolic mesentery was done in order to remove the regional lymph nodes. The ileocolic and right colic arteries and veins were divided and ligated at their origins from the superior mesenteric artery and vein. The middle colic artery and vein with their left branches were preserved to supply the region of the ileotransverse colostomy. The right branch of these vessels was sacrificed so that additional transverse mesocolon and lymph nodes could be resected. The distal end of the stomach, the duodenum and the head of the pancreas were mobilized in this order. Since the beginning of the third portion of the duodenum lies directly on the inferior vena cava, extreme care was taken not to damage this large vessel. A number of small veins connecting the two structures were carefully ligated and divided. The resection of the duodenum was carried to the point where the superior mesenteric vessels cross it. After it was divided between clamps the distal end was closed with two rows of sutures.

The head of the pancreas was mobilized with the duodenum, and it was resected at its junction with the body. This exposed the portal vein at its origin, formed by the junction of the splenic and superior mesenteric veins. These vessels were preserved with the utmost care, since ligation of the portal vein will rapidly produce death. The pancreatic duct was isolated in both cases and ligated with a fine cotton ligature. The dissection as described permitted the removal en masse of the tumor with the distal half of the stomach, the duodenum, the head of the pancreas, the terminal ileum, the cecum, the ascending colon, the right half of the transverse colon and the attached ileocolic and transverse mesocolons.

The common bile duct in both cases was divided near the upper border of the first portion of the duodenum. The method of reestablishment of the biliary circulation into the intestine was different in the 2 cases. A choledochojejunostomy with a jejunojejunostomy distal to the gastrojejunostomy after the method of Roux, as advised by Whipple,[4a] was performed in the first case. This was feasible because the common bile duct was considerably dilated. The choledochojejunostomy was performed around a T tube, a step which furnished a safety valve and at the same time prevented temporary blockage of the anastomosis by edema (fig. 2). In the second case the duct was too small to make a satisfactory anastomosis to the jejunum. Accordingly a cholecystojejunostomy was performed. In order to simplify the anastomosis it was carried out between the gallbladder and the jejunum proximal to the gastrojejunostomy. The gallbladder was mobilized by freeing the fundus of it from the liver bed (fig. 4). This was necessary in order to make the anastomosis without tension on the suture line. An attempt in this case was made to mobilize the distal portion of the duodenum to anastomose it with the gallbladder, as described by Dennis[5] and Pearse,[6] but this was impossible because of the congenital anomaly involving the upper part of the jejunum. Both types of anastomoses used in these patients functioned satisfactorily, but the type in the second case seems preferable since it is less complicated, requiring only one anastomosis and at the same time giving protection against the regurgitation of intestinal contents into the biliary tract, similar to the Roux type of anastomosis. In addition bile enters the intestinal tract proximal to the gastrojejunostomy, so that the acid gastric juice is neutralized, with the result that there is theoretically less danger of the development of a gastrojejunal or jejunal ulceration.

The severed end of the pancreas in both cases was sutured with interrupted mattress sutures of fine cotton after the main pancreatic duct was ligated with the same material. The raw area resulting from the removal of the organs was peritonealized as much as possible in order to prevent the small intestine from becoming adherent to it and producing intestinal obstruction. The abdominal cavity in both cases was drained with gauze wicks surrounded with soft rubber tubing. These drains were placed posterior to the new peritoneal floor and brought out through stab wounds in the right flank. This method gave dependent drainage with little

4a. Whipple, A. O.: Present Day Surgery of the Pancreas, New England J. Med. **226**:515 (March 26) 1942.

5. Dennis, C.: A Modified Whipple Operation for Carcinoma of the Head of the Pancreas, Surgery **12**: 201 (Aug.) 1942.

6. Pearse, H. E.: A Simplified Anastomosis for Resection of the Duodenum and Head of the Pancreas, Surg., Gynec. & Obst. **75**:333 (Sept.) 1942.

chance of puddling and secondary infection. It also permitted the suturing of the main abdominal wound intact and prevented the profuse drainage, which so often occurs in this type of case, from interfering with the healing of it, an extremely important consideration since wound disruption is most apt to occur in patients who are in as poor a state of nutrition as these were.

In both cases large amounts of pancreatic secretions drained for about four weeks, after which the drainage ceased. Neither patient appeared to suffer greatly from the loss of the external secretion of the pancreas, but it is believed that some type of pancreojejunal anastomosis is desirable in resections of this type. It is possible that in both cases spontaneous internal pancreojejunal fistulas developed, which would best explain the cessation of the drainage.

The type of incisions used requires special attention since it is important to have as few peritoneal adhesions as possible in the operative field at the second operation, to facilitate the extensive resection that must be carried out. Accordingly at the first stage a left paramedian incision was used which permitted adequate exposure for determining the operability of the main lesion and, at the same time, the carrying out of the gastrojejunostomy and the ileotransverse colostomy without disturbing the peritoneal cavity to the right of the midline, where the dissection must be done for the second stage. The use of a transverse incision for the second stage extending well out into the right flank and across the midline to the left permitted the dissection to be done posteriorly with greater ease than if a vertical incision had been employed.

Extensive surgical procedures, such as the second stage operation performed on these patients, are likely to be accompanied by surgical shock. This results from the extensive dissection in the splanchnic area, the loss of moderately large amounts of blood and the prolonged anesthesia. The most effective way to combat surgical shock is the maintenance of an effective volume of blood by multiple transfusions. The first patient received one transfusion of 500 cc. before the first stage procedure and six between this operation and the second stage over a period of sixteen days. During the second operation he was given two transfusions and an additional two postoperatively the same day, a total of 2,000 cc. of blood. The next day he received another 1,000 cc. and during the remainder of his convalescence he was given two more transfusions of 500 cc., each in an attempt to raise the serum protein level. This patient received a total of fifteen transfusions of 500 cc., or a total of 7,500 cc. of blood. The second patient received two transfusions of 500 cc. before the first stage procedure and two more the day it was performed. This large amount was given because his red blood count was 2,000,000 before the operation. After the four transfusions it rose to 3,500,000. Between the two stages he received five additional transfusions. During the second stage operation three transfusions were given, then two additional ones postoperatively on the same day, so that he received a total of 2,500 cc. of blood during that day. At the end of the first two and one-half hours of the operation his blood pressure had fallen from 130 systolic and 90 diastolic to 75 systolic and 50 diastolic, and his pulse rate had risen from 90 to 132. At the end of the five hour operation the blood pressure had risen to 100 systolic and 60 diastolic, and the pulse rate had dropped to 112, showing the beneficial effect of a transfusion of 1,500 cc. of blood. With the two additional postoperative transfusions his blood pressure rose and maintained a level of 125 systolic and 80 diastolic with a pulse rate of 110. During his postoperative convalescence he received three additional transfusions. This patient received a total of seventeen transfusions of 500 cc., or a total of 8,500 cc., of blood.

When planning such extensive surgical operations as these patients were subjected to, it is of prime importance to have available large amounts of blood for multiple transfusions. Without this precaution surgical shock will develop, from which patients will succumb even though a technically perfect operation has been performed. The modern blood bank with facilities for the storage of blood, established in many of the large hospitals, makes available these large quantities of blood on short notice, which was not possible when the older method of transfusion was used by drawing the blood from the donor when it was needed. Once surgical shock has developed and persisted for several hours, it may represent an irreversible reaction. whereas by the early administration of transfusions it may be possible to prevent its development. The administration of large transfusions, in one case 1,000 cc. and in the other 1,500 cc., during the course of the operation is emphasized especially as a method to prevent severe or fatal shock, since by this means an effective volume of blood is maintained during the critical period when all the factors of anesthesia, trauma of the operation and loss of blood are acting to produce shock. The use of multiple transfusions before and after the operations also is important

in order to improve the patient's condition by correcting anemia and aiding in the maintenance of or increasing the serum protein level.

Both patients were placed in an oxygen tent for forty-eight hours postoperatively to prevent anoxia, which if present would contribute to shock. Proper fluid and electrolyte balance was maintained with solutions given by the intravenous route containing 5 per cent dextrose in isotonic saline solution and 5 per cent dextrose in distilled water, so that a urinary output of at least 1,000 cc. was obtained. To these solutions vitamins B, C and K were added in the form and amount respectively of 50 mg. of thiamine chloride, 1 Gm. of cevitamic acid and 4 mg. of water-soluble vitamin K. For the second patient after the jejunostomy these substances were mixed with the jejunostomy feedings, since they could be given more readily and in less expensive form. In order to build up this patient's serum protein amigen was given intravenously until the jejunostomy functioned and then it was given by this route.

Serious postoperative infection did not develop in either case. It is believed that the local use of sulfanilamide intraperitoneally at the time the tumor was resected and the postoperative intravenous administration of sulfadiazine played an important part in preventing this complication. A sulfadiazine level of 8 to 10 mg. per hundred cubic centimeters of blood was maintained postoperatively for a week and then the drug was discontinued. Jaundice developed postoperatively in the second case. It is believed this was the result of combining the use of intraperitoneal administration of sulfanilamide and intravenous administration of sulfadiazine in a patient with a poor liver reserve, since the sulfanilamide is picked up rapidly by the portal system, so that the sulfonamide level in the portal blood is undoubtedly much higher than in the systemic blood and may be of sufficient concentration to produce a toxic hepatitis, especially if sulfadiazine is given concomitantly, as occurred in this patient. For this reason it is now considered preferable to use only sulfadiazine administered by the intravenous route, or if sulfanilamide is used intraperitoneally sulfadiazine therapy should not be commenced until the first postoperative day.

Deep venous thrombosis of the legs is a postoperative complication seen frequently in patients following abdominal operations for a malignant disease. The condition is a serious threat to life from fatal pulmonary embolism. In each of the patients reported on this condition developed in both legs following the first stage operation. In order to prevent pulmonary embolism, bilateral interruption of the femoral veins in the groins was performed with the patient under local procaine hydrochloride infiltration anesthesia as soon as the diagnosis of phlebothrombosis was made, as advocated by Allen et al.[7] Despite the fact that the extensive second stage operations were carried out following the occurrence of this complication, signs of pulmonary embolism did not develop in either patient after interruption of the femoral vein. It would seem justifiable in similar cases to advocate prophylactic interruption of the femoral veins during the first stage operation or shortly thereafter.

SUMMARY

The surgical extirpation of carcinoma of the right side of the colon, producing a duodenocolic fistula, requires resection of the distal portion of the stomach, the duodenum, the head of the pancreas, the terminal ileum, the ascending colon and the proximal half of the transverse colon.

It is advisable to divide the operative procedure into two stages, since patients with this lesion are in a poor nutritional state, the result of carcinoma and a high intestinal fistula and because highly infectious fecal material is present in all the lumens of the bowel which it is necessary to transect. The first stage consists of transection of the stomach and ileum and the formation of a gastrojejunostomy and an ileotransverse colostomy to by-pass the duodenocolic fistula. The second stage consists of a block extirpation of the primal growth with the involved organs. This necessitates colectomy on the right side and in addition the resection of the organs which it is necessary to remove in performing a Whipple type of operation for carcinoma in the head of the pancreas.

The successful outcome of this major operation, in addition to the technical details, depends, first, on adequate preoperative preparation of the patient; second, on the care of the patient during the operation, including the type of anesthesia and the prevention of shock, and third, on the postoperative measures to prevent shock and infection and to maintain an adequate fluid and electrolyte balance. In the preoperative preparation, anemia should be corrected with blood transfusions; a low serum protein level should be elevated by transfusions and intravenous administration of amino acids, and in some cases a jejunostomy should be performed for feeding purposes; avitaminosis should be corrected by the parenteral and oral administration of vitamins B, C and K.

7. Allen, A. W.; Linton, R. R., and Donaldson, G. A.: Thrombosis and Embolism, Ann. Surg. **118**: 728 (Oct.) 1943.

The care of the patient during the operation should include the selection of a safe and satisfactory anesthetic. Since the operations require several hours, ether administered through an endotracheal tube fulfils the necessary requirements and permits in addition the administration of oxygen during the operation. Surgical shock should be prevented by massive blood transfusions.

In the immediate postoperative period additional transfusions are necessary to prevent shock. The use of an oxygen tent in this critical period to prevent anoxia is an important adjunct in treatment. The intravenous administration of sulfadiazine to combat postoperative infection should be used. Fluids, dextrose and electrolytes should be given in sufficient quantities to maintain a daily urinary output of 100 cc.

Phlebothrombosis of the lower extremities with the danger of pulmonary embolism is a common complication in patients with abdominal carcinoma requiring such major procedures. Fatal pulmonary embolism can be prevented, if this complication develops, by interruption of the femoral vein on both sides. It is suggested that this procedure may be carried out as a prophylactic measure at the first stage operation.

MEDIASTINAL GANGLIONEUROMA

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The division of the mediastinal space into three compartments is a delineation which serves more than its originally pure anatomic purpose. Tumors arising in each of these spaces bear certain marks of distinction which permit of their general classification according to situation. Thus the anterior mediastinum is the site of election for dermoid and thymoma. The middle mediastinum is the site of bronchogenic carcinoma and lymphosarcoma. From the structures of the posterior mediastinum arise lymphosarcoma and neoplasms such as neurofibroma and ganglioneuroma whose origin may broadly be considered under the term "neurogenic." Neurofibroma is a relatively common tumor; ganglioneuroma, although somewhat of a curiosity, is important from the standpoints of etiology, diagnosis and prognosis.

Although Knoebellanch in 1846 reported the first "ganglioneuroma," in the case of "neuroma" reported by Odier in 1803 the lesion undoubtedly was a ganglion cell tumor. It was early recognized that ganglioneuroma can arise from elements within the central nervous system, the peripheral nervous system, the sympathetic and parasympathetic systems and the medullary portion of the suprarenal gland.[1] The majority of the tumors, however, appear to originate within the sympathetic chains and therefore usually are situated in the cervical region, the posterior mediastinum, the posterior wall of the abdomen or the posterior aspect of the pelvis. These tumors are often multiple and sometimes occur in conjunction with other tumors of nervous origin.[2] Mediastinal ganglioneuroma is rare, but in the last twenty-five years, with exploratory thoracotomy becoming more and more common, this tumor has been reported more frequently.[3]

Bohrer and Lincoln [4] expressed the opinion that this tumor is rare among children, but in most of the reported cases the patients have been less than 30 years of age. No difference in the incidence in the two sexes has been noted. Bigler and Hoyne,[5] as well as other authors, have found that as a general rule the more advanced the patient's age the greater is the likelihood for the tumor to be benign. As pure ganglioneuroma is usually benign one would expect that it would occur rarely among children.

CLINICAL PICTURE

Many authors stress the absence of symptoms, and cases have been reported in which a mediastinal ganglioneuroma had been present for eighteen to twenty years without causing symptoms. At times the tumor is first discovered when routine roentgenograms of the thorax are made. In many cases, however, there are symptoms that are referable to the tumor, and a careful inquiry reveals that the symptoms in question have been present for months or years. These symptoms are often ingravescent. Ganglioneuroma does not invade the blood vessels, lymphatics or contiguous structures, but produces symptoms by pressure on the adjacent vessels and organs. Pressure on the trachea may cause a persistent cough, dyspnea and even stridor with

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1. Wohl, H. R.: Neuroblastomata, with a Study of a Case Illustrating the Three Types That Arise from the Sympathetic System, J. M. Research **30**:205-260 (May) 1914.

2. Wohl, H. R., and Craig, P. E.: Multiple Tumors of the Sympathetic Nervous System: Report of a Case Showing a Distinct Ganglioneuroma, a Neuroblastoma and a Cystic Calcifying Ganglioneuroblastoma, Am. J. Path. **14**:797-807 (Nov.) 1938.

3. Allison, P. R., and Carmichael, R.: A Case of Mediastinal Ganglioneuroma, Brit. J. Surg. **27**:175-179 (July) 1939. Cooley, L. E., and McNamara, F. P.: Intrathoracic Ganglioneuroma, J. Iowa M. Soc. **30**: 117-120 (March) 1940. Harvey, W. C.: Case of Ganglionic Neuroma of the Mediastinum in a Child Aged Nine, Lancet **1**:405-406 (Feb. 22) 1930. Ganglioneuroma, Cabot Case 24422, New England J. Med. **219**: 620-623 (Oct. 20) 1938. Rosenson, W.: Neoplasms of the Mediastinum in Infancy and Childhood: Report of a Case of Ganglioneuroma of the Mediastinum in a Girl of Eight Years, Am. J. Dis. Child. **26**:411-417 (Nov.) 1923.

4. Bohrer, J. V., and Lincoln, E. M.: Ganglioneuroma of the Chest in Children: A Report of a Case with a Review of the Literature, J. Thoracic Surg. **3**:365-373 (April) 1934.

5. Bigler, J. A., and Hoyne, A.: Ganglioneuroma: Report of Two Cases with a Review of the Literature, Am. J. Dis. Child. **43**:1552-1571 (June) 1932.

cyanosis. Some of the commonest symptoms, and often the earliest ones, are those due to pressure on the inferior laryngeal nerves: a change in the quality of the voice, a brassy cough and, much later, stridor. Encroachment on the bronchi may produce cough and the physical signs of decreased aeration. A generalized sensation of tightness or fulness in the thorax is often described by the patient harboring a growing mediastinal tumor. Dysphagia is rare, probably owing to the ease with which the esophagus accommodates itself to pressure. Edema of the upper half of the body, facial cyanosis and dilatation of the superficial veins may result from partial occlusion of the superior vena cava by pressure from a mediastinal ganglioneuroma. Involvement of the superior cervical ganglion causes enophthalmos, ptosis, miosis and lack of sweating (Horner's syndrome) on the homolateral side and is often seen in cases of ganglioneuroma of the superior mediastinum. Bizarre symptoms referable to the spinal cord may be due to pressure from a dumbbell-shaped tumor, which has grown into the spinal canal through an intervertebral foramen. Hart and Ellison [6] observed the Pel-Ebstein type of fever among children who had a ganglioneuroma of the mediastinum. Cervical tumors are seen in conjunction with mediastinal ganglioneuroma at times, and these cervical masses are usually nerve tumors arising from the cervical portion of the sympathetic nervous system.

ROENTGENOLOGIC FINDINGS

Roentgenographically, the tumor appears as a dense homogeneous ovoid shadow arising in the posterior part of the thorax. The lateral border of the shadow is convex and sharply defined, while the medial border adjacent to the vertebral column is definitely flattened. The lateral view shows that the mass arises in the posterior gutter of the thorax (the site of the sympathetic chain). No invasion of contiguous structures is seen, although the adjacent ribs or vertebrae may show thinning or erosion, owing to pressure from the tumor. Rarely, the tumor may grow through an intervertebral foramen and enlarge the foramen. Dolley and Jones [7] recommended artificially induced pneumothorax to show that the tumor is extrapulmonary.

DIAGNOSIS

The typical picture is a mediastinal tumor which may be silent and found only accidentally or by compression may cause a variety of symptoms, the most common being brassy cough, dyspnea and stridor. The patient's good general condition, the lack of signs of metastasis and the extremely slow growth of the tumor all point to a ganglioneuroma.

Differential Diagnosis.—Diving goiter must be ruled out. This usually can be done by examining the patient's neck while he is swallowing. Mediastinal cysts may simulate ganglioneuroma in all respects, but only rarely are they encountered in the posterior gutter, whereas ganglioneuroma always arises posterior to the plane of the trachea. Dermoid cysts in the mediastinum are almost universally encountered in the anterior mediastinum. Mediastinal lymphoblastoma, especially Hodgkin's disease, may simulate ganglioneuroma. High voltage roentgen therapy serves to distinguish the two conditions, as irradiation has no effect on ganglioneuroma. Neurofibroma is supposedly distinguished from ganglioneuroma by the erosion of ribs and of the intervertebral foramens in the former condition; however, the same changes are encountered in ganglioneuroma.

TREATMENT

The only satisfactory treatment is surgical removal of the tumor. Irradiation with roentgen rays and radium is useless.

Bohrer and Lincoln recommend the establishment of an artificial pneumothorax two weeks before operation for the purpose of showing the presence of pleural adhesions, stabilizing the mediastinum and shunting the blood to the contralateral lung.

Complete excision is desirable, although some authors state that leaving part of the capsule of the tumor does not affect the prognosis. Excision is often made difficult by the presence of large blood vessels running over or through the tumor. At times, the tumor is firmly adherent to adjacent ribs or vertebrae and can be removed only by excision of the involved bony structures.

The entire thoracic sympathetic chain should be examined as ganglioneuromas are often multiple and even an examination of the entire thoracic chain does not exclude their presence in the abdomen or pelvis.

The posterior approach is the better one as the tumor originates in the posterior mediastinum and the great vessels lie between an anterior approach and the tumor.

An intercostal incision usually suffices although one or more ribs may have to be resected if the tumor is large, especially if the ribs are firmly adherent to the growth. Some surgeons close the thorax without drainage while others insert a soft rubber catheter.

6. Hart, F. D., and Ellison, P. O.: Mediastinal Ganglio-Neuroblastoma, abstracted, Proc. Roy. Soc. Med. **30**:1195-1198 (Aug.) 1937.

7. Dolley, F. S., and Jones, J. C.: Surgical Treatment of Tumors of Lung and Mediastinum, Am. Rev. Tuberc. **39**:479-487 (April) 1939.

It is often extremely difficult or impossible to mobilize or remove a mediastinal ganglioneuroma, because of its dense attachment to contiguous ribs or the bodies of the vertebrae. In addition, undue force cannot be exerted in their separation because of the danger of injuring important adjacent blood vessels and nerves.

COMPLICATIONS

Hemorrhage at times complicates the removal of mediastinal ganglioneuromas owing to their proximity to the large vessels of the posterior mediastinum.

As in any intrathoracic operation, infection is to be feared but rarely complicates operations on these tumors as they are extrapleural.

Eloesser [8] reported the removal of a mediastinal ganglioneuroma and the connected nerve; a meningopleural fistula and meningitis developed, but the patient recovered.

Various types of complications referable to the spinal cord may occur if a dumbbell-shaped tumor lies partly within the spinal column.

Riggs and Good [9] reported a case in which fatal suffocation was due to tracheal obstruction by a contiguous ganglioneuroma.

Recurrence of these tumors is denied by James and Curtis [10] and by Bohrer and Lincoln; however, many authors believe that they tend to recur, especially if they are incompletely removed. Malignant changes occur and metastasis has been encountered by Sophian [11] and by Clarke.[12]

PATHOLOGY

Grossly, ganglioneuroma resembles uterine fibromyoma in color and consistency. It is usually encapsulated, although Sophian said that the capsule is often incomplete. Occasionally, it is lobulated; certain tumors are dumbbell shaped. Multiple tumors are sometimes seen, and often a single nerve or plexus of nerves is attached to one or more of the tumors. Hart described an outer yellow white cortex and an inner medulla showing regions of hemorrhage and necrosis. Microscopically, the tumor is mainly composed of fusiform cells arranged compactly; the nuclei are oval or round, are small and stain deeply with hematoxylin and eosin. Scattered throughout are islands of ganglion cells with little supporting fibrous tissue, but frequently surrounded by numbers of so-called satellite cells. The nerve fibers are mostly nonmedullated and often arranged in bundles. A greater number of axis cylinders than ganglion cells is often observed and is said to be due to degeneration of previously existing ganglion cells. The ganglion cells may be mononuclear or multinuclear, and Nissl granules can be demostrated within the cytoplasm, as is often seen in the normal state. Pigmentation, degeneration or calcification of the ganglion cells is seen not infrequently. The tumor matrix is almost avascular white fibrous connective tissue.

Crile and Ball,[13] Haven and Weil,[14] Clarke and others described changes in the tumor which varied from the presence of primitive neuroblasts to adult ganglion cells. Such a tumor is probably best called ganglioneuroblastoma, as designated by Hart; such a designation has the advantage of denoting the malignant potentialities of the tumor in contradistinction to the "benign" pure ganglioneuroma.

REPORT OF CASES

We report 3 cases of mediastinal ganglioneuroma that were observed at the Mayo Clinic in one year.

CASE 1.—The patient was a 9 year old boy whose family and past history were unimportant. Six months before the patient came to the clinic his appetite had become poor and two months before his examination at the clinic he had had an attack of influenza. Roentgenograms of the thorax at that time had disclosed a thoracic tumor. During the week before his visit to the clinic he had had shooting pains in the left side of the thorax.

The results of physical examination were negative except for dulness to percussion and decreased breath sounds at the base of the right side of the thorax posteriorly and laterally. The value for the hemoglobin was 11.2 Gm. per hundred cubic centimeters of blood. The results of other tests, including Kahn's test, determination of the sedimentation rate and a tuberculin test, were normal.

Anteroposterior and lateral roentgenograms of the thorax disclosed a mass in the lower posterior portion of the right side of the thorax. There apparently was some pressure erosion of the inferior border of the tenth rib near the costovertebral juncture (fig. 1).

The diagnosis was ganglioneuroma of the right side of the thorax.

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8. Eloesser, L.: Meningopleural Fistula Following Extirpation of a Ganglioneuroma of the Upper Mediastinum: Ganglioneuroma of the Adrenal Gland, S. Clin. North America **13**:1325-1336 (Dec.) 1933.

9. Riggs, T. F., and Good, L. P.: Ganglioneuroma of Mediastinum Requiring Surgical Intervention for Relief of Obstructive Symptoms, Arch. Surg. **19**:309-320 (Aug.) 1929.

10. James, A. G., and Curtis, G. M.: Mediastinal Ganglioneuroma, Ann. Surg. **113**:767-776 (May) 1941.

11. Sophian, L.: Mediastinal Ganglioneuroma, Ann. Surg. **101**:827-833 (March) 1935.

12. Clarke, J. M.: Large Thoracic Ganglio-Neuroma, Australian & New Zealand J. Surg. **8**:199-202 (Oct.) 1938.

13. Crile, G. W., and Ball, R. P.: Primary Nerve Tumors of Neck and Mediastinum, Surg., Gynec. & Obst. **48**:449-460 (April) 1929.

14. Haven, H., and Weil, A.: Multiple Ganglioneuroma, Arch. Path. **13**:713-715 (May) 1932.

Fig. 1.—Roentgenographic appearance of ganglioneuroma in case 1; *a*, anteroposterior view showing discrete tumor in the lower medial part of the right half of the thorax; *b*, lateral view showing tumor arising in the posterior mediastinum.

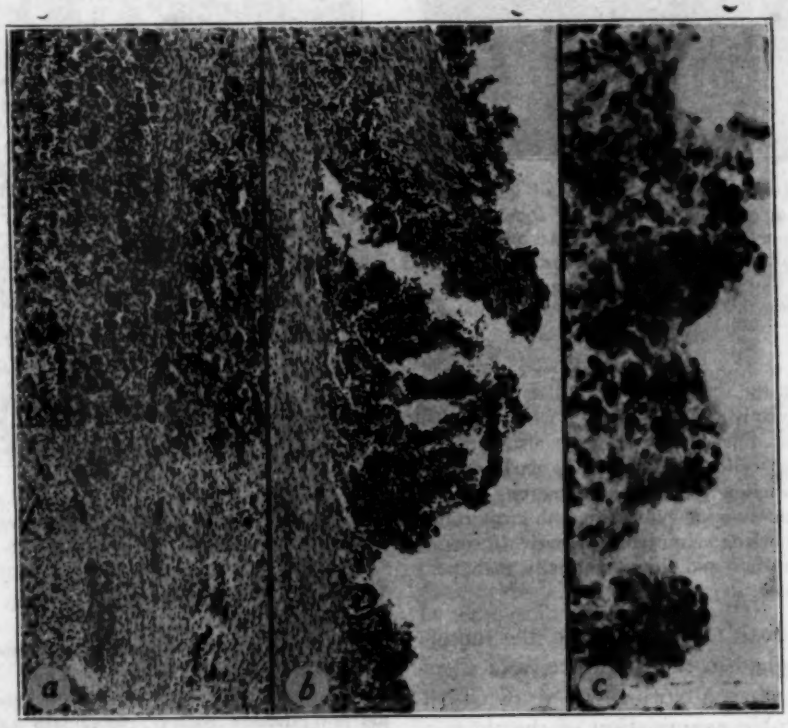

Fig. 2.—Photomicrographs of ganglioneuroma in case 1; sections stained with hematoxylin and eosin; *a*, numerous ganglion cells surrounded by amyelinated nerve fibers; no malignant cells are visible (× 45); *b*, dark portions show primitive (malignant) neuroblasts (× 45); *c*, primitive neuroblasts (× 200).

Operation.—The right pleural space was opened by a curved incision in the ninth intercostal space on the right side. A smooth tumor 6 by 4 by 3 cm. was seen in the right posterior gutter; it was densely attached to the right lateral aspect of the bodies of the vertebrae. The tumor was dissected free with difficulty. The wound was closed without drainage. Convalescence was uneventful.

Pathologic Aspects.—Grossly, the tumor consisted of a lobulated dense tough fibrous mass measuring 6 by 4 by 3 cm. Its color varied from white to yellow. The appearance was quite similar to that of a uterine fibromyoma which had undergone fatty degeneration.

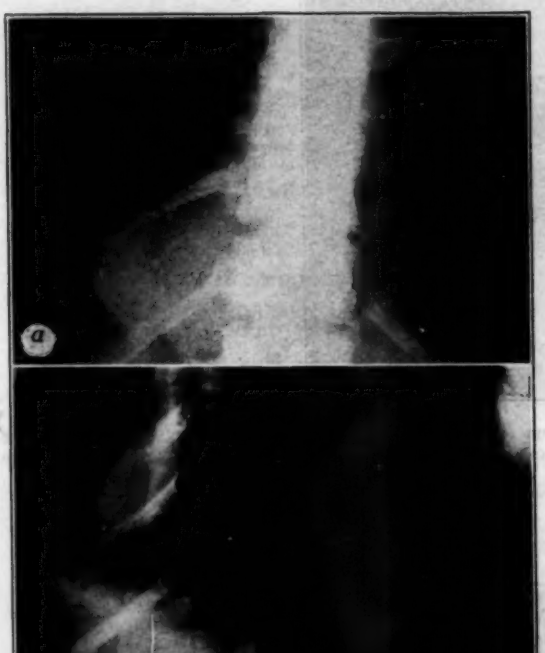

Fig. 3.—Roentgenographic appearance of ganglioneuroma in case 2; *a*, anteroposterior view showing large circumscribed tumor in lower medial part of the right half of thorax; the sharply defined shadow is rather characteristic of that produced by a ganglioneuroma; *b*, oblique view showing tumor in the posterior mediastinum.

Microscopically, there was an avascular stroma of white fibrous connective tissue through which coursed numerous amyelinated nerve fibers. There also appeared numerous elongated cells with large oval dark-staining nuclei. Large ganglion cells were numerous. They contained clear, light-staining cytoplasm with large round nuclei containing nucleoli. Numerous primitive forms of nerve cells (neuroblasts and thus potentially malignant cells) were seen (fig. 2).

Comment on Case 1.—In this case, the tumor, like many mentioned in the literature, was silent and found only when attention was drawn to it by roentgenographic examination of the thorax. It is said that the younger the patient the greater the likelihood that the tumor contains more primitive (malignant) cells. The finding of such cells in this tumor supported this contention.

Case 2.—The patient was a married woman 35 years of age. She had sustained an injury to her back ten years before she came to the clinic; this had not confined her to bed but she had had minor backache at irregular intervals since the injury. Two months before she came to the clinic she had undergone cholecystectomy and appendectomy; since the operation she had had a constant aching in the midline of the lower part of the back. The pain had extended into her shoulders and had been aggravated by standing or sitting. She came to the clinic because of this backache.

The results of physical examination were negative except for dulness to percussion and absence of breath sounds over a triangular area in the posterior part of the right side of the thorax.

The results of laboratory examinations, including urinalysis, an erythrocyte count, a leukocyte count, estimation of the value for the hemoglobin, a Kahn test and determination of the sedimentation rate, were normal in all respects. Roentgenograms of the thorax revealed a sharply defined soft tissue mass in the posterior part of the right side of the thorax at the cardiophrenic angle (fig. 3). The upper margin of the tumor extended to the body of the twelfth thoracic vertebra; the lower portion was not visible. The tumor was intrathoracic and contiguous to the spinal column. It did not interfere with diaphragmatic excursion. There appeared to be some erosion of the lower anterior corner of the body of the ninth thoracic vertebra at its external surface. Roentgenoscopic examination did not reveal

Fig. 4.—Photomicrograph of ganglioneuroma in case 2; scattered ganglion cells are surrounded by bundles of amyelinated neurons. No malignant nerve cells are visible. Section stained with hematoxylin and eosin (× 45).

any pulsation of the tumor. The preoperative diagnosis was neurofibroma.

Operation.—The right pleural space was opened through an incision in the right tenth interspace. This revealed a soft tumor, 10 by 15 cm., in the right retropleural region along the borders of the ninth thoracic to the eleventh thoracic vertebrae. The tumor was densely adherent to the thoracic wall and bodies of the vertebrae and could not be dissected free. A specimen was removed for biopsy, and the wound was closed without drainage.

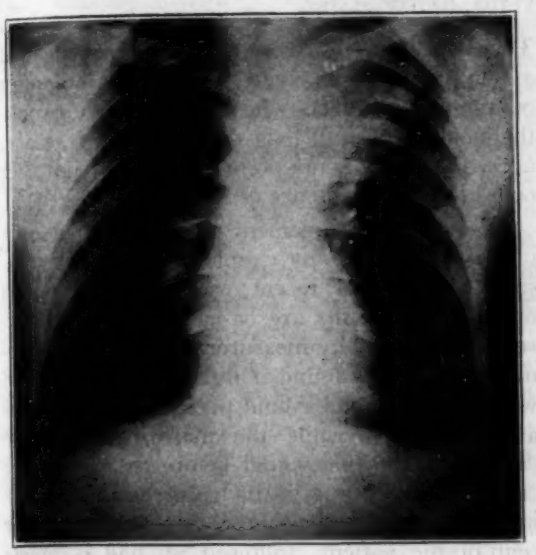

Fig. 5.—Roentgenogram of ganglioneuroma in case 3.

Pathologic Aspects.—The microscopic structure of the tumor was the same as that of the tumor in case 1, except that the ganglion cells were much less numerous (fig. 4). No neuroblastic elements were encountered.

Comment on Case 2.—It is doubtful that the tumor had any relation to the backache as the patient was much improved when seen three months after operation. This tumor represents the type described in the literature as being impossible of removal owing to the dense adherence to bony structures.

Case 3.—The patient was a single man 26 years of age. His past history was unimportant. On routine roentgenographic examination of the thorax conducted at an army camp, a thoracic tumor was discovered.

Physical examination disclosed only dulness to percussion over the posterior superior portion of the left half of the thorax. The results of laboratory examinations, including urinalysis, estimation of the value for the hemoglobin, an erythrocyte count, a leukocyte count, a Kahn test and determination of the sedimentation rate, were normal. Roentgenograms of the thorax revealed a well circumscribed tumor in the left superior part of the left half of the thorax. The tumor had caused erosion of the vertebral portions of the fourth and fifth ribs and separation of these ribs with widening of the intercostal space. The roentgenologic diagnosis was a neurofibroma rising from the fourth thoracic trunk or fourth intercostal nerve on the left (fig. 5). Roentgenographic examination of the thoracic and cervical vertebrae did not reveal any evidence of intraspinal extension of the tumor. The preoperative diagnosis was intrathoracic neurofibroma.

Operation.—A curved incision was made along the vertebral border of the left scapula. The scapula was retracted medially, and most of the left fifth rib was removed from the angle anteriorly. The tumor measured 14 by 8 by 7 cm. and was densely adherent to the left lateral aspect of the second to the sixth thoracic vertebrae and corresponding ribs in the posterior gutter. The tumor was so densely adherent to the fourth rib on the left side that the posterior 7 cm. of the rib was removed with the tumor. The wound was closed without drainage. Convalescence was uneventful.

Pathologic Aspects.—The gross appearance of the tumor was quite similar to that in case 1. Sections of various portions of the tumor were practically identical with the sections obtained in case 1 but ganglion cells were much less frequent. No malignant cells were seen (fig. 6).

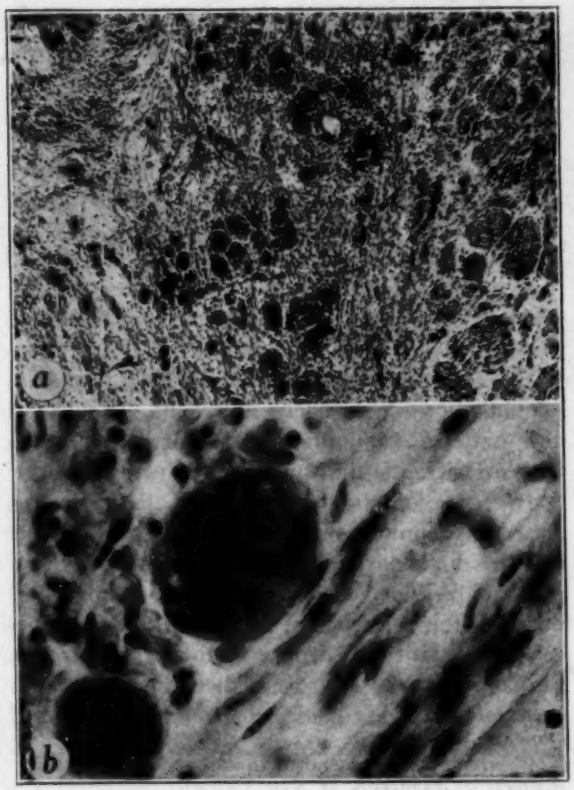

Fig. 6.—Photomicrographs of ganglioneuroma in case 3; sections stained with hematoxylin and eosin; *a*, characteristic ganglion cells arranged in groups and surrounded by amyelinated nerve bundles (× 45); *b*, section containing two large ganglion cells whose cytoplasm is filled with Nissl bodies; the small dark cells are the periganglionic "satellites" (× 435).

Comment on Case 3.—As is commonly the case, the tumor was discovered quite by accident and had caused no symptoms. Its removal was difficult owing to its dense adherence to the bony structures of the thoracic cage.

PROGRESSIVE EXOPHTHALMOS IN TOXIC DISEASE OF THE THYROID GLAND

A REVIEW OF THE RECENT LITERATURE, WITH THE REPORT OF A CASE OF PROGRESSIVE POST-THYROIDECTOMY PROPTOSIS IN A SIX YEAR OLD NEGRO GIRL

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Exophthalmos has been recognized as a phase of the syndrome of hyperthyroidism literally since the recognition of the disease, as the nomenclature of exophthalmic goiter shows. Persistent or progressive post-thyroidectomy exophthalmos has been recognized as a possible undesirable and a potentially serious sequel of the operation almost from the time the surgical treatment of hyperthyroidism was introduced. The successful therapy of postoperative exophthalmos, however, is little more than a decade old, and intensive study of the problem of both preoperative and postoperative proptosis has been carried out for an even shorter time, so short a time, in fact, that Means's [1] statement in 1942 that "a new specialty of endocrinologic ophthalmology is a-borning" seems unduly optimistic.

CAUSATION OF EXOPHTHALMOS ASSOCIATED WITH HYPERTHYROIDISM

Statements concerning the clinical aspects of exophthalmos are widely divergent. Paulson [2] and Cattell [3] could find no correlation between the severity of the hyperthyroidism and the degree of exophthalmos, though Cattell demonstrated a definite correlation between its degree and the duration of the thyroid disease. Plummer and Wilder [4] stated that in large groups of patients the severity of the proptosis can be correlated with the severity of the hyperthyroidism, as shown by high basal metabolic rates and weakness of the quadriceps femoris muscles. There is now fairly general agreement that exophthalmos is likely to be most severe after operation in subjects whose preoperative exophthalmos has been of long duration, and it is also agreed that it does not occur either before or after operation in the absence of toxicity.

There is no agreement as to the incidence of post-thyroidectomy exophthalmos, chiefly because, as several recent writers have pointed out, few statements are based on accurate measurements if on any measurements at all. Plummer and Wilder found it difficult to understand why a few patients should present exophthalmos after operation while the majority lose such degrees as they presented before thyroidectomy and show no signs of its recurrence. Cattell, in a statistical study, stated that almost 75 per cent of the patients followed up had complete or partial relief from their preoperative exophthalmos. Lehman [5] considered postoperative improvement due rather to disappearance of spasm of the levator muscles and narrowing of the palpebral fissures than to recession of the eyes. He also cited Ruedemann's observations, based on careful measurements, to the effect that the average postoperative recession amounts to only 2 mm.

The studies of Soley [6] and of Galli-Mainini [7] in 1942 support Lehman's observations. Soley, who emphasized that the loss of stare associated with hyperthyroidism does not necessarily mean a decrease in exophthalmos, showed by exophthalmometric measurements that the eyes of over 50 per cent of patients with diffuse toxic goiter become measurably more prominent after subtotal thyroidectomy, and also showed that recession occurs in only a small percentage of cases.

From the 64th General Hospital, and from Charity Hospital of Louisiana at New Orleans.

1. Means, J. H.: Diseases of the Thyroid Gland, New England J. Med. **227**:594-602 (Oct. 15) 1942.

2. Paulson, D. L.: Experimental Exophthalmos and Muscle Degeneration Induced by Thyrotropic Hormone, Proc. Staff Meet., Mayo Clin. **14**:828-832 (Dec. 27) 1939.

3. Cattell, R. B.: Eye Complications in Exophthalmic Goitre: Cataracts and Exophthalmos, Ann. Surg. **100**:284-303 (Aug.) 1934.

4. Plummer, W. A., and Wilder, R. M.: Etiology of Exophthalmos: Constitutional Factors with Particular Reference to Exophthalmic Goiter, Arch. Ophth. **13**:833-852 (May) 1935.

5. Lehman, J. A.: Hyperthyroidism in Children, West. J. Surg. **44**:528-534 (Sept) 1936.

6. Soley, M. H.: Exophthalmos in Patients with Various Types of Goiter, Arch. Int. Med. **70**:206-220 (Aug.) 1942.

7. Galli-Mainini, C.: Exophthalmometric Measurements in Patients with Thyroid Diseases with Some Discussion of Their Significance, Ann. Int. Med. **16**: 415-426 (March) 1942.

Galli-Mainini concluded, also on the basis of exophthalmometric measurements, that while patients with no history of exophthalmos during the course of their illness present normal measurements after thyroidectomy, those with recognized protrusion during the active phase of their illness always have some postoperative persistence of the exophthalmos.

The various theories advanced to explain exophthalmos include: (1) sympathetic overactivity; (2) relaxation of the extraocular musculature; (3) contraction of smooth muscle in the floor of the orbit; (4) vascular abnormalities, including dilatation of the orbital vessels with congestion of the vascular bed of the orbit, and retrobulbar venous engorgement; (5) increase in the orbital fat; (6) edema of the normal orbital contents, which may or may not be associated with edema of the extraorbital structures, and hypertrophy of the extraocular muscles (so-called hypertrophic myositis).

Most of these theories receive little credence at this time, although certain cases are observed in which even the most unlikely does not seem inapplicable. Cattell,[3] for instance, pointed out that the apprehensive or actually frightened expression of a subject with hyperthyroidism suggests a sympathetic influence, while the rapidity with which gross exophthalmos often disappears after correction of hyperthyroidism suggests a nervous origin rather than anatomic intraorbital change. Actually, however, the theory of sympathetic overactivity has little to support it.

The theory of increased vascularity suggested by Trousseau[8] in 1865 and by Filehne[9] in 1879 was based on the experimental observation that enucleation of normal eyes was not attended by the profuse hemorrhage which occurred when similar operations were performed on exophthalmic rabbits. Daily and his associates[10] have recently reported a case in which the same phenomenon was observed; venous congestion was so marked while decompression was being done that constant suction was necessary to keep the operative field clear. Eagleton,[11] after a detailed discussion of the anatomy and blood supply of the orbit, reasoned that a physiologic increase in the amount of blood within the retrobulbar space is promptly compensated for as long as the veins and arteries possess their normal contractile properties, but that retention of arteriovenous blood within the limited intraorbital space necessarily results in exophthalmos. The theory is not universally applicable and does not explain the case to be reported herewith.

The most commonly accepted explanation of exophthalmos is the theory of local structural edema, which may be associated with muscular hypertrophy. These theories do not necessarily conflict with the theory of increase in the orbital fat. As several recent writers have pointed out, older reports are based on gross inspection and not on histologic examination, which, had it been carried out, might have revealed precisely the same changes reported by more modern writers. Another prolific source of confusion is the fact that muscle sections are notoriously difficult to interpret.

Edema of the orbital tissues in exophthalmos was first mentioned by Jones[12] in 1860, and in the last several years it has been repeatedly described in the still sparse histologic studies made in such cases. The first really comprehensive investigations were made by Naffziger,[13] who removed 20 specimens of muscle in the course of ten decompression operations. In every instance, apparently from a combination of edema and hypertrophy, the structures were from three to ten times larger than normal. The muscles frequently felt hard and were sometimes rubbery hard and fibrotic. In the most advanced cases the tissue was gritty to the knife. Histologic changes included in varying degree swelling of the muscle fibers, loss in striations, definite interstitial edema, lymphocytic infiltration and scar tissue. Naffziger's examinations were unusually complete, and permitted the statement that early, intermediate and late stages of pathologic change may all be found in the same tissue. Failure to confirm his observations by some writers may perhaps be due to less complete examinations. Whatever the reason, discrepancies have been reported. Thomas and Woods[14] found hypertrophy of the muscle in only 1 of 3 recent cases and slight enlargement and degeneration in only 1 of 6 restudied specimens. On

8. Trousseau, cited by Swift.[23]

9. Filehne, cited by Swift.[23]

10. Daily, R. K.; Daily, L.; Walker, J. D., and Peterson, H. J.: Exophthalmic Ophthalmoplegia, South. M. J. **35**:344-352 (April) 1942.

11. Eagleton, W. P.: Exophthalmos from Surgical Diseases, Especially as to Involvement of the Protective Retrobulbar Space, Arch. Ophth. **14**:1-40 (July) 1935.

12. Jones, cited by Means.[1]

13. Naffziger, H. C.: Progressive Exophthalmos After Thyroidectomy, West. J. Surg. **40**:530-543 (Oct.) 1932.

14. Thomas, H. M., and Woods, A. C.: Progressive Exophthalmos Following Thyroidectomy, Bull. Johns Hopkins Hosp. **59**:99-113 (Aug.) 1936.

the other hand, Ellett [15] found muscular hypertrophy in both of his cases, Daily and his associates [10] found it in 2 of 3 cases, Klemme [16] found it in 1 of 2 cases, and Semmes,[17] in a single case, found the muscles ten times normal size. While muscular hypertrophy is thus not universal, edema is generally observed. It was the only obvious explanation of the exophthalmos in the case reported herewith, in which degenerative changes were also observed.

Experimental exophthalmos comparable to human exophthalmos has been extremely difficult to produce, and only the use of pituitary extract has been in any way successful. Since recent studies supply considerable support of the theory of edema, with or without associated muscular hypertrophy, one or two may be briefly mentioned. Smelser,[18] for instance, by injections of beef pituitary extract, was able to produce definite and sometimes extreme exophthalmos in from twelve to twenty days in 47 of 50 thyroidectomized young adult guinea pigs. The exophthalmos varied in degree but was roughly proportionate to the amount of pituitary extract used. It did not disappear post mortem but often became more pronounced as the lids relaxed, particularly in the group of animals in which cervical sympathetic ganglionectomy had also been done. The histologic changes in the experimental animals were identical with those in 2 clinical cases observed by Smelser, in both of which the eyes were lost because of corneal damage. Except for degenerative changes they were also similar to the observations reported by Naffziger. Smelser concluded that the changes which he observed were secondary and were caused by mechanical or toxic factors inherent in lowered tissue nutrition.

Aird [19] produced experimental exophthalmos in guinea pigs by intraperitoneal injections of various extracts of anterior pituitary gland containing the thyrotropic fraction. It progressed slowly and irregularly, but persisted after the injections had been discontinued as well as during narcosis and after death. Myopathy of the extraocular muscles was sufficient to account for both the degree and the permanence of the proptosis, and it was Aird's opinion that it was qualitatively consistent with changes found in the extraocular muscles of human subjects with malignant exophthalmos.

Paulson [2] observed protrusion of the eyeballs within twenty-four hours after the first injection of an anterior pituitary extract which contained potent quantities of thyrotropic factor (antuitrin T.), in 80 per cent of intact animals and in all thyroidectomized animals. The mean percentage of water in the retrobulbar tissues of treated animals, exclusive of the lacrimal glands, was 6.37 per cent greater than in the tissues of intact animals, although the percentage in the lacrimal glands and in the skeletal and cardiac muscles of treated animals was not significantly greater than in similar tissues of untreated control animals.

MODERN CONCEPTS OF EXOPHTHALMOS ASSOCIATED WITH HYPERTHYROIDISM

Both experimental and pathologic evidence thus points to edema of the orbital structures, with or without muscular hypertrophy, as a reasonable explanation of exophthalmos. Even after this fact has been established, however, several problems still remain to be solved. One is the fundamental cause of the edema. Here the recent studies of Means and his associates [20] and the speculations based on them throw considerable light. These authors, who conceive of exophthalmic goiter as a state of "total endocrine imbalance," call attention to the fact that the thyroid and its hormone and the anterior pituitary gland and its thyrotropic (thyroid-stimulating) hormone are apparently concerned with water balance as well as with metabolism. The thyroid hormone has been shown to promote diuresis and the thyroid-stimulating hormone of the pituitary to promote storage of water. Since the hormonic balance can be altered in more than one way, these authors do not find it unreasonable that in certain cases of exophthalmic goiter the nature of the imbalance is such that storage of water is the chief manifestation or that the consequences of such storage in the orbit, because of limitations of space, may be disastrous.

The most difficult problem of all is why exophthalmos progresses after thyroidectomy in a cer-

15. Ellett, E. C.: Unilateral Exophthalmos, J. A. M. A. **116**:1-7 (Jan. 4) 1941.

16. Klemme, in discussion on Swift, G. W.: Malignant Exophthalmos and Operative Approach, West. J. Surg. **43**:119-126 (March) 1935.

17. Semmes, in discussion on Naffziger, H. C., and Jones, C. W.: The Surgical Treatment of Progressive Exophthalmos Following Thyroidectomy, J. A. M. A. **99**:638-642 (Aug. 20) 1932.

18. Smelser, G. K.: A Comparative Study of Experimental and Clinical Exophthalmos, Am. J. Ophth. **20**:1189-1203 (Dec.) 1937.

19. Aird, R. B.: Experimental Exophthalmos and Associated Myopathy Induced by the Thyrotropic Hormone, Ann. Int. Med. **15**:564-581 (Sept.) 1941.

20. Means, J. H.; Hertz, S., and Williams, R. H.: Graves' Disease with Dissociation of Thyrotoxicosis and Ophthalmopathy, Tr. A. Am. Physicians **56**:67-74, 1941.

tain small proportion of cases, since in the majority, even if it does not completely regress, it at least becomes stationary or shows no gross increase. The once accepted idea that it is progressive because sufficient thyroid tissue has not been removed is scarcely tenable in view of the fact that removal of additional tissue often not only does not correct the condition but may, as in the reported case, be followed by further aggravation of the proptosis.

Thomas and Woods [14] have correctly emphasized that hypothyroidism is scarcely a reasonable explanation since exophthalmos is never observed after total thyroidectomy for heart disease. Seitchik's [21] suggestion that post-thyroidectomy exophthalmos is caused by an increased secretion of thyrotropic hormone in subjects in a hypothyroid state is purely theoretic.

The observations of Means and his associates,[20] however, seem to throw considerable light on postoperative exophthalmos. In addition to their concept of hyperthyroid disease as a state of "total endocrine imbalance," they have made two classifications of the disease. In one, the classic variety, thyrotoxicosis is the major problem. In the other, which they have named "Graves' disease with dissociation of thyrotoxicosis and ophthalmopathy" and which they call the "special ophthalmic type" as a matter of convenience, ophthalmologic considerations are predominant. Indeed, as in the case reported herewith, the patient frequently first seeks medical attention on account of his eyes. There are also other differences between this type and the classic type:

1. Thyrotoxicosis is mild, absent, or readily controlled. This criterion does not fit the reported case, in which toxicity was severe and was extremely difficult to control.

2. Enlargement of the gland is not notable.

3. Males are affected relatively more often than females, though exophthalmic goiter is more frequent in females than in males.

4. Response to iodine is superstandard, the basal metabolic rates often reaching minus levels. This occurred in the reported case, in which, however, the levels were never unusually high in view of the child's extreme toxicity.

5. The ocular signs differ somewhat from those of the classic type, in which the conspicuous features are exophthalmos, lid lag and lid retraction. In the special ophthalmic type of case exophthalmos is relatively slight, but there may be marked periocular edema, chemosis of the conjunctiva sometimes accompanied by massive swelling, injection of the conjunctiva and smarting and excessive watering. Ophthalmoplegia and diplopia are also frequent. Most of these signs were present in the reported case, in which, however, the classic ocular signs were also present and in which exophthalmos was marked.

21. Seitchik, J. N.: Mechanism of the Production of Exophthalmos in Exophthalmic Goiter, Arch. Ophth. 27:762-775 (April) 1942.

THERAPY

The methods of attacking exophthalmos collected by Naffziger [15] in 1932 included such palliative procedures as tarsorrhaphy and canthotomy, incision of the lid and plastic operations on the conjunctiva, and such radical procedures as removal of the periorbital fat and the Krönlein operation. Cervical sympathetic ganglionectomy has been advocated, but the results are so poor that the operation has been generally discarded, and Hernández Ramírez and Hernández's [22] report of a successful case is distinctly out of the ordinary.

The operation which Naffziger [12] devised in 1932 after one of his patients with progressive exophthalmos had committed suicide has given generally good results in the limited number of cases in which it has been employed. It is, however, a serious procedure, as is shown by the fatal outcome in the reported case, in which it was done by an experienced neurosurgeon. Swift's [23] method of decompression through a lateral approach is also a serious procedure.

Sewall,[24] in studying the Naffziger technic, realized that an equal or even greater amount of space about the orbit might be gained by utilizing the neighboring sinuses. He therefore devised an operation which consists of incision through the skin of the orbit, entrance into the frontal and ethmoid sinuses, complete removal of the orbital walls, exenteration of the ethmoid cells and resection of the floor of the orbit. Kistner [25] employed this operation in 2 of his 3 cases and considers that it has several advantages over the Naffziger operation. Daily and his associates,[10]

22. Hernández Ramírez, R., and Hernández, N. A.: Residual Exophthalmos After Thyroidectomy in Basedow's Disease: Cervical Sympathectomy, Arch. de oftal. de Buenos Aires **15**:58-64 (Feb.) 1940; abstracted, Am. J. Ophth. **25**:369 (March) 1942.

23. Swift, G. W.: Malignant Exophthalmos, Tr. Am. A. Study Goiter, 1935, pp. 1-10.

24. Sewall, E. C.: Operative Control of Progressive Exophthalmos, Arch. Otolaryng. **24**:621-624 (Nov.) 1936.

25. Kistner, F. B.: Decompression for Exophthalmos: Report of Three Cases, J. A. M. A. **112**:37-38 (Jan. 7) 1939.

however, have pointed out that if the frontal sinuses are small, the Naffziger operation promises better results.

The obvious defect of even the best of these operations is that it is directed toward correcting a condition which has already developed and is not concerned with its prevention. Such preventive measures as are available are not entirely satisfactory. Bandaging, the use of cotton pledgets and of supersaturated petrolatum gauze, and lubrication of the eyes during anesthesia are appropriate measures in all cases but are merely palliative. Opinions differ as to the value of cellophane shields, which Ruedemann [26] recommends. He has pointed out the illogic of suture of the lids; edema cannot be corrected by this method and pressure will only be magnified against the cornea or the sutures. He has sometimes found it useful to bring up the lower lid by Frost's method, using a collodion dressing to help support the skin of the face.

If the views of Means and his associates [20] are accepted, the idea that increasing exophthalmos is an indication for immediate thyroidectomy is no longer tenable. The poor results which frequently follow operation seem to support their opinion that thyroidectomy is the measure most definitely contraindicated in this variety of hyperthyroidism and feeding of thyroid the method most definitely indicated. The basis of the latter suggestion is their personal experimental studies, which show that thyroidectomy promotes retention of water, while feeding of thyroid promotes diuresis.

Means and his group have outlined a plan of therapy for patients with the "special ophthalmic type" of hyperthyroidism, which includes the use of both iodine and thyroid extract, the former for its effect on the basal metabolic rate and the latter for its diuretic effect. If thyrotoxicosis is so extreme that it must be treated, irradiation is preferred to thyroidectomy, which should be a last resort, on the ground that it has a more gradual effect on the hormonal balance and therefore permits a more gradual readjustment of the optic structures. Means and his associates also used irradiation of the pituitary gland in 1 case, with good results, the rationale of the method being their concept of the role of the thyroid-stimulating hormone in the "special ophthalmic type" of goiter. If edema of the orbit is of sudden onset or if it is extreme, diuretics may be useful as a temporary measure, or repeated lumbar puncture may be carried out.[27]

26. Ruedemann, A. D.: Exophthalmos: Bilateral Exophthalmos in Adults, Cleveland Clin. Quart. **3**:281-291 (Oct.) 1936.

Soley,[6] whose work was presented at about the same time as that of Means and his associates, in general shares these views. His concept is that the only reasonable explanation for progressive exophthalmos after thyroidectomy is the rapid change from a state of hyperactive function of the thyroid to a normal or subnormal state. He also advocates the substitution of irradiation for thyroidectomy as a more gradual method of bringing about this change.[27]

Feeding of thyroid for progressive exophthalmos after thyroidectomy has been tried with varying results. Thomas and Woods [14] used this method in 5 of their 15 cases with no effect at all, and the results at the Mayo Clinic, where it has been used in combination with iodine therapy since 1922, do not seem to be striking.[28] On the other hand, Willard Bartlett Jr.[29] has reported success with it in 2 cases, in 1 of which there was almost complete loss of vision. In the other, intense edema about the orbit was part of a general myxedema. The results might perhaps be better if Bartlett's warning were generally heeded that feeding of thyroid be instituted without delay when an increase in exophthalmos is observed after thyroidectomy. It seems scarcely necessary to emphasize that if this method is used, either before or after operation, there should be frequent determinations of the basal metabolic rate.

REPORT OF A CASE

These studies, most of which are recent, seem to throw light on a case of exophthalmic goiter with progressive post-thyroidectomy proptosis observed a number of years ago in a young Negro child at the Charity Hospital of Louisiana at New Orleans. Had they been available at the time, the outcome of the case might possibly have been different.

History.—A. D., a Negro girl aged 6, was brought to Charity Hospital of Louisiana at New Orleans Sept. 23, 1936 because "her eyes were coming out of her head." Until nine months before she had been a healthy, active child. Then her parents first observed bilateral protrusion of the eyes; it had progressed gradually until two weeks before her admission to the hospital, after which progress had been rapid. Three months before admission it was observed that she had become extremely nervous and was constantly covered with

27. Means, J. H.: The Eye Problems in Graves' Disease, Illinois M. J. **80**:135-138 (Aug.) 1941.

28. Haines, in discussion on Paulson.[2]

29. Bartlett, in discussion on Naffziger, H. C., and Jones, C. W.: The Surgical Treatment of Progressive Exophthalmos Following Thyroidectomy, J. A. M. A. **99**:638-642 (Aug. 20) 1932.

perspiration. She had lost a great deal of weight in these three months, although her appetite had become progressively larger. The only subjective complaint was palpitation.

Examination.—Physical examination showed a well developed child, who had apparently lost considerable weight. She was quiet and unusually intelligent for her age and race, but seemed apprehensive. The temperature was 99.6 F., the pulse rate 136 and the respiratory rate 32 per minute and the blood pressure 110 systolic and 40 diastolic. There was visible pulsation of the vessels of the neck, and the heart was slightly enlarged; a soft systolic murmur was heard in the aortic, pulmonic and tricuspid areas.

The expression was fixed and staring and bilateral exophthalmos (graded plus 4) was present. The pupils were equal and regular and reacted to light and in accommodation. The palpebral fissures were greatly widened. Ocular signs included lid lag, inability to converge and failure of the forehead to wrinkle when the patient looked up. Visual acuity was within normal range.

Urinalysis, serologic tests of the blood and spinal fluid and roentgenologic examination of the skull revealed no abnormalities. Examination of the blood showed 4,650,000 red cells and 12,350 white cells per cubic millimeter. The hemoglobin was 90 per cent. Roentgenologic examination of the chest revealed an enlargement of the cardiac shadow in the transverse diameter. The initial basal metabolic rate was plus 26.

Treatment and Preoperative Course.—Treatment consisted of complete rest in bed, a high caloric diet, fluids by mouth pushed to the limit of toleration and fluids given parenterally as necessary to maintain the proper fluid balance. Administration of strong solution of iodine U. S. P. in doses of 5 minims (0.3 cc.) three times daily was begun on September 30.

For a few days there was considerable improvement, though the pulse rate was never less than 120 per minute. Then nervous symptoms and restlessness became increasingly marked, there were daily elevations of temperature to 102.5 F., the pulse rate rose to 168 per minute, diarrhea was profuse, and by October 5 the child was in clearcut crisis. Administration of iodine was discontinued and routine measures for the control of crisis were instituted. Transient improvement was followed by a second crisis, but after October 20 improvement was continuous, though the pulse rate was seldom lower than 120 to 140 per minute.

Medication with strong solution of iodine had been resumed in 5 minim doses three times a day on October 11. After October 20 it was given in 10 minim (0.6 cc.) doses three time a day in cycles of four days of medication and one day of rest. After November 25 it was discontinued entirely. The basal metabolic rate, originally plus 26, was minus 4 on October 8, minus 32 on October 22 and plus 24 on November 23. Examination of the blood on October 25 showed 4,960,000 red cells and 9,250 white cells per cubic millimeter. The hemoglobin was 100 per cent. The cholesterol content of the blood on October 29 was 170 mg. per hundred cubic centimeters.

Management of the exophthalmos, which had increased steadily since the child's admission to the hospital, had meantime become a serious problem. On October 15 marked bilateral conjunctivitis and episcleritis were observed. A fold of edematous conjunctiva protruded from the lower portion of each eyeball, overhanging the lower lid and preventing closure of the eyes. The left eye showed a beginning ulceration of the cornea with some infiltration of the lower third, probably from exposure and "strangulation." There was a moderate bilateral purulent discharge. Conservative measures, including hot compresses, boric acid ointment and taping of the lids produced so much improvement that tarsorrhaphy, which had been advised on October 24, was postponed.

First Operation.—The left lobe of the thyroid, which was now stony hard, probably as the result of long-continued therapy with iodine, was removed on December 3. The immediate postoperative course was stormy but after the fourth day improvement was continuous, and the patient was dismissed from the hospital on Dec. 27, 1936. At this time the basal metabolic rate was plus 27. The condition of the right eye was fairly satisfactory but the left eye showed an opacity at the site of the corneal infiltration.

Serial tests of the function of the liver by the Quick hippuric acid test had been carried out and were interpreted as indicative of grave and possibly permanent damage to the liver. The highest value, 67 per cent of normal, was obtained immediately after the child's admission to the hospital. During the periods of crisis the values fell to 50 and later to 25 per cent of normal. After lobectomy the value was less than 20 per cent of normal, and when she was dismissed it had risen to only 30 per cent of normal.

Fig. 1.—*A*, progressive bilateral exophthalmos eleven months after lobectomy. *B*, progressive exophthalmos of left eye two months after evisceration of right eye and thirty-five days after second stage thyroidectomy.

Second Admission.—The child was brought back to the hosiptal on Nov. 1, 1937, eleven months after the first operation. She had gained some weight and was in generally better health. The temperature was 99 F., the pulse rate 100 and the respiratory rate 24 per minute, and the blood pressure 130 systolic and 88 diastolic. The thyroid gland was moderately enlarged, especially on the right side.

The eyes had not shared in the general improvement but had become progressively more protuberant. A week before the child's return the right eye had become reddened and painful, and a day or two later some discharge was noted. Examination showed a marked bilateral exophthalmos (fig. 1*A*). The conjunctiva of the right eye was greatly reddened, there was a grayish exudate over the cornea, and a moderately profuse yellowish discharge was present, a smear from which revealed numerous pus cells but no bacteria. A diagnosis of panophthalmitis was made and evisceration was stated to be inevitable, but because of improvement under conservative therapy it was postponed until November 12.

Second Operation.—On November 12 the right eye was eviscerated. By this time the left eye was slightly injected. It was treated with continuous boric acid compresses and boric acid ointment three times a day and less than 20 per cent of normal on two succeeding occasions, which confirmed the original impression of grave and probably permanent damage to the liver. Administration of strong solution of iodine was begun

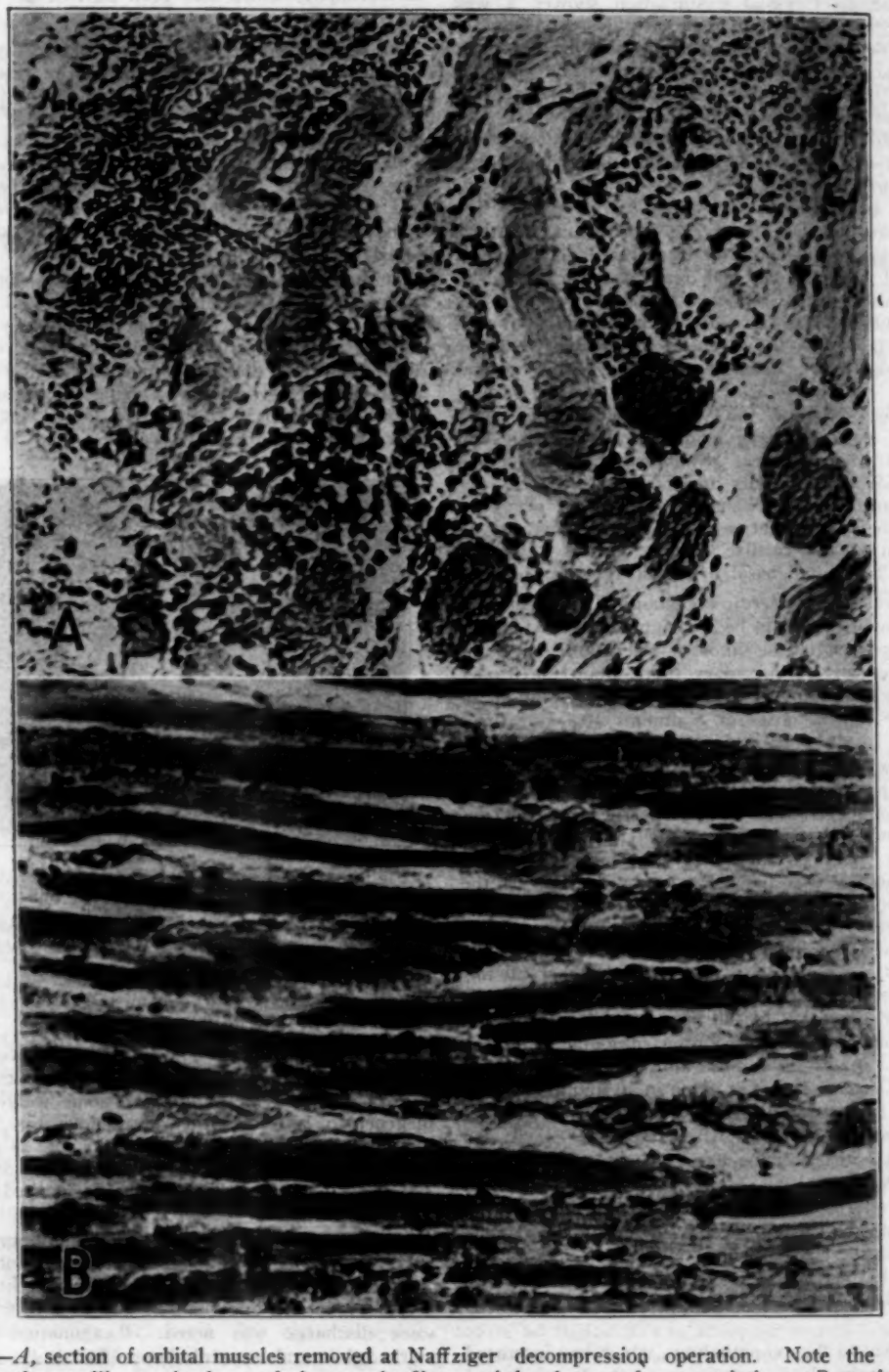

Fig. 2.—*A*, section of orbital muscles removed at Naffziger decompression operation. Note the lymphocytic infiltration, the swelling and edema of the muscle fibers and the absence of cross striations. *B*, section of orbital muscles removed at autopsy nine days after Naffziger decompression operation. Note the absence of lymphocytic infiltration and the less marked edema of the muscle fibers. Cross striations, although indistinct, are now present.

and, a little later, by instillations of atropine sulfate ointment and daily bandaging.

The result of the Quick hippuric acid test of function of the liver was 33 per cent of normal on the initial test in 10 minim doses three times a day on November 29, and by December 8 the basal metabolic reading was 0.

Third Operation.—On December 9 lobectomy was performed on the right side with the patient under solution

of tribromethanol-ether anesthesia. Recovery was fairly smooth, the maximum pulse rate being 154 per minute. Postoperative therapy included a transfusion of 250 cc. of whole blood.

The child's general condition showed considerable improvement after operation, though her appetite continued insatiable and there was no corresponding gain in weight. The pulse rate varied between 100 and 120 per minute. She was permitted to be up most of the time and played about the ward with the other children.

In the meantime, however, the condition of the remaining eye continued to deteriorate (fig. 1 *B*). Intraocular pressure was normal, and the fundi and pupillary reflexes were also normal, but the orbital tissues showed extreme tension and edema. Exophthalmos progressed to such a degree that the lids no longer covered the eyeballs, corneal ulceration was also progressive, and keratitis developed.

Fourth Operation.—On Jan. 11, 1938, when it was clear that no results could be expected from conservative therapy and that only radical measures might save the remaining eye, the Naffziger unroofing operation, preceded by tarsorrhaphy, was carried out under local anesthesia with solution of tribromoethanol. The operation was without incident except for a slight tearing of the dura. The orbital fat and ocular muscles were markedly edematous and a section of the superior rectus muscle (fig. 2 *A*) was reported on as follows: "The muscle fibers are somewhat edematous and pale. Cross striations are not observed. A small amount of hemorrhage is present. A slight lymphocytic infiltration is observed."

The postoperative course was uneventful for twenty-four hours. On the second day the temperature rose to 104 F. and the pulse rate to 160 per minute. On the third day a spinal tap revealed bloody cerebrospinal fluid under pressure of 14 mm. of mercury. On the fifth day infection of the scalp wound was evident; the sutures were removed, and the wound was opened widely. Symptoms of meningitis became progressively clear-cut, and death occurred from this cause on the ninth postoperative day.

Autopsy.—Postmortem examination revealed acute leptomeningitis, abscess of the left frontal lobe of the brain, extreme fatty metamorphosis of the liver and cloudy swelling of the convoluted tubules of the kidney. The optic structures (fig. 2 *B*) were reported on as follows: "The optic nerve and the coats of the eyeball show no abnormalities. The extraocular muscles are pale and slightly edematous. Their cross striations are invisible. The nuclei are large and vesicular."

COMMENT

Aside from its ophthalmologic aspects, this case is of interest for other reasons. Toxic thyroid disease in very young children is unusual, and in very young Negro children it is even more unusual. In Boyce's [30] study of thyroid disease at the New Orleans Charity Hospital over a recent twelve and a half year period there were 183 cases of toxic goiter in Negroes, only 2 of which, including the reported case, occurred in children under 15 years of age. The other child, incidentally, a girl 8 years old, died on the operating table. A casual search of the literature has revealed no other instance of progressive post-thyroidectomy exophthalmos in a young colored subject.

Of the devastating character of this patient's toxicity there can be no doubt. It was evidenced by her extreme nervousness; her voracious appetite with continued loss of weight or lack of gain of weight; her constantly elevated pulse rate, respiratory rate and temperature; the crises which developed on two occasions, and the degree of damage to the liver demonstrated ante mortem by serial tests of function and confirmed by postmortem examination. The case, unfortunately, was handled at a most unpropitious time, when the new Charity Hospital was in course of construction. During this period the makeshift buildings in which the population was housed were hopelessly overcrowded, especially those for Negroes, and the special nursing, isolation and quiet, which are among the cardinal principles of the management of hyperthyroidism, were impossible of achievement. The child had to be kept in an open ward, in most of the beds of which there were at least 2 patients. Boyce [30] and Maes and Romano [31] have called attention to the difficulties attending the treatment of hyperthyroidism during this period, and Boyce has reported 4 cases of adults in which the noise and confusion incident to the hospital construction seemed to play a definite part in the fatal outcome.

It should also be pointed out that the child's parents disregarded the instructions given them when she was dismissed after the first operation, and ten months (instead of three) had elapsed and irreparable damage to the eyes had occurred before she was brought back for further treatment.

The optic tissues removed at operation showed edematous changes, which were also present, though to a lesser degree, in the tissues removed at postmortem examination (fig. 2). The case thus seems, in most respects, to fit into the "special ophthalmic type" of goiter described by Means and his associates.[20] It may be that the use of irradiation rather than thyroidectomy, as advocated by these authors and by Soley,[6] might have saved the child's eyes and ultimately her life, though this comment, of course, is not intended as a criticism of the treatment employed, which met all the criteria for the therapy of

30. Boyce, F. F.: Thyroid Disease in the Southern Negro: A Comparative Analysis of 470 White and 482 Negro Cases from Charity Hospital of Louisiana at New Orleans, Surg., Gynec. & Obst. **70**:761-767 (April) 1940.

31. Maes, U., and Romano, S. A.: Thyroid Disease in a Nonendemic Area: A Third Series of Observations, Ann. Surg. **111**:275-284 (Feb.) 1940.

exophthalmic goiter as it was then conceived. On the other hand, the child's toxicity was of such a degree that it presented a threat to life and was in the beginning an even more serious problem than her progressive exophthalmos. Whether the outcome of the case might have been different had the child's parents brought her back at the appointed time, so that the second lobectomy could have been performed promptly, is another matter for speculation.

SUMMARY AND CONCLUSIONS

The treatment of exophthalmos associated with hyperthyroidism, particularly of the variety which becomes progressive after thyroidectomy, has hitherto been unsatisfactory.

Thyroidectomy, far from correcting the condition, frequently seems to aggravate it.

Recent studies indicate that the cause of exophthalmos in hyperthyroidism is local edema, sometimes associated with hypertrophy of the extraocular muscles.

The proposal that irradiation be substituted for thyroidectomy is based on the theory that with a less abrupt alteration in the endocrine balance there is a greater chance for more gradual readjustment of the optic structures.

A case of progressive post-thyroidectomy exophthalmos is reported and is analyzed in the light of these new concepts. It is unusual because of the extreme youth and the race (Negro) of the patient.

LATERAL ABERRANT THYROID: METASTASIS TO THE LYMPH NODES FROM PRIMARY CARCINOMA OF THE THYROID GLAND

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BALTIMORE

For over fifty years cystic papillary growths of thyroid tissue in the lateral cervical region have been recognized, but the interpretation placed on them has almost uniformly been that they represent embryonically misplaced thyroid tissue. This explanation is implicit in the term in Shrager's [1] generally accepted nomenclature, "lateral aberrant thyroid." Recently it has been shown clearly by King and Pemberton [2] that these "lateral aberrant thyroid" masses are in reality metastases from a carcinoma of similar structure in the thyroid gland itself.

The following 2 cases recently seen at the Johns Hopkins Hospital confirm the work of King and Pemberton. While 2 cases constitute a small series, they are reported as additional evidence that papillary cystic thyroid tissue in the lateral cervical region is often metastatic from an identical primary tumor in the thyroid. Since the primary tumor may be extremely small, exploration of the thyroid and removal of at least the homolateral lobe are indicated.

REPORT OF CASES

CASE 1.—A white man 21 years old first came under observation in October 1941. He had always been well. In the course of a routine physical examination a mass 3 cm. in diameter was palpated deep in the right supraclavicular region. When removed two weeks later it was found to lie beneath the sternocleidomastoid muscle.

The specimen was a brownish, cystic, gelatinous, encapsulated mass measuring 2 by 2 by 3 cm. and was thought to be lateral aberrent thyroid tissue. Microscopic examination revealed a papillary cystadenocarcinoma of thyroid tissue in a lymph node together with less differentiated masses of epithelial cells invading the capsule and the remaining lymphoid follicles and sinuses (fig. 1). The final diagnosis was "carcinoma invading cervical lymph node and capsule of papillary cystadenoma of aberrant thyroid."

The patient remained well and repeated roentgenograms showed that his chest was normal. He was followed in the outpatient department. In May 1943, eighteen months after the first operation, in the course of another routine physical examination, a firm mass was felt in the right supraclavicular region. An exploration of the neck was performed a few days later and two masses, each 1.5 cm. in diameter, were found. One lay beneath the internal jugular vein and the second inferiorly and posteriorly in the posterior mediastinum. The right lobe of the thyroid was exposed and found by palpation to contain two small nodules in the posterior part. This lobe was accordingly removed. The opposite lobe was normal to palpation and was left in place.

Examination of the specimens revealed that in the right lobe of the thyroid there was a tumor 1 cm. in diameter, and loosely attached to the lower margin of the lobe was another 5 mm. in diameter. These nodules proved to be identical with the lesion removed from beneath the sternocleidomastoid muscle nineteen months before (fig. 2). The cervical nodules were clearly metastases in lymph nodes from the tumor in the thyroid. Remnants of the lymph nodes could be seen at the margins of the metastases. The primary lesion in the thyroid and all the metastases contained cystic papillary areas, acinus-forming areas with colloid, and foci of solid undifferentiated tumor cells. There were also small scattered foci of calcification in all the lesions.

The patient has been treated with irradiation since his discharge, remains well, and shows no recurrence six months after operation. His lungs remain clear and no calcified foci can be seen in the neck or mediastinum on roentgen examination.

CASE 2.—A white woman, aged 26, was first seen in 1937 complaining of a swelling in the left side of her neck. It had been present for four years and was growing larger. Her health had been excellent and the past family histories were noncontributory. Physical examination revealed three masses at the posterior border of the left sternocleidomastoid muscle said to be comparable in size to a lemon, a hen's egg and a walnut respectively. Biopsy of one of these masses showed what was thought to be a papillary tumor of thyroid tissue, probably arising in aberrant thyroid tissue (fig. 3*A*). Accordingly all the masses, which were found to be encapsulated, were subsequently excised. The thyroid was exposed and was thought by the operator to be normal. Microscopically the excised masses were identical with the tissue in the biopsy specimen, and the final diagnosis was papillary cystadenoma of aberrant thyroid.

In connection with the study of case 1 in June 1943, the microscopic sections from case 2 were reviewed. In all of them a good deal of lymphoid tissue was found, mostly about the periphery of the nodules. In some sections the lymphoid tissue contained germinal centers and lymph sinuses, which clearly indicated that it was not simply lymphoid follicles which are sometimes found in papillary tumors of the thyroid, but the residue of lymph nodes containing metastases from the

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From the Surgical Pathology Laboratory of the Departments of Pathology and Surgery of the Johns Hopkins University.

1. Shrager, V. L.: Lateral Aberrant Thyroids, Surg., Gynec. & Obst. **3**:465, 1906.

2. King, W. L. M., and Pemberton, J. de J.: So-Called Lateral Aberrant Thyroid Tumors, Surg., Gynec. & Obst. **74**:991, 1942.

tumor in the thyroid gland. A letter to the patient elicited the information that a slowly growing lump had been noticed in her neck for one year. For this reason she was requested to return and was admitted to the hospital in October 1943, six years after her first operation.

Physical examination on this occasion revealed a firm nodular mass, 4.5 by 3 cm., at the lower pole of the left lobe of the thyroid gland, but no palpable lateral cervical masses were felt. At operation the nodule was found in the lower pole of the left lobe, of the thyroid and that in the lateral cervical region, there were two small nodules, 1 and 3 mm. in diameter, in the right lobe of the gland. Microscopic sections showed that the large tumor was a papillary cystadenocarcinoma (fig. 3 *B*), while the extrathyroid mass was a metastasis in a lymph node, as evidenced by germinal centers and lymph sinuses in the surrounding lymphoid tissue (fig. 3 *C*). These structures were histologically identical with the metastases removed six years previously. The nodules in the right lobe were also small foci of papillary cystadenocarcinoma.

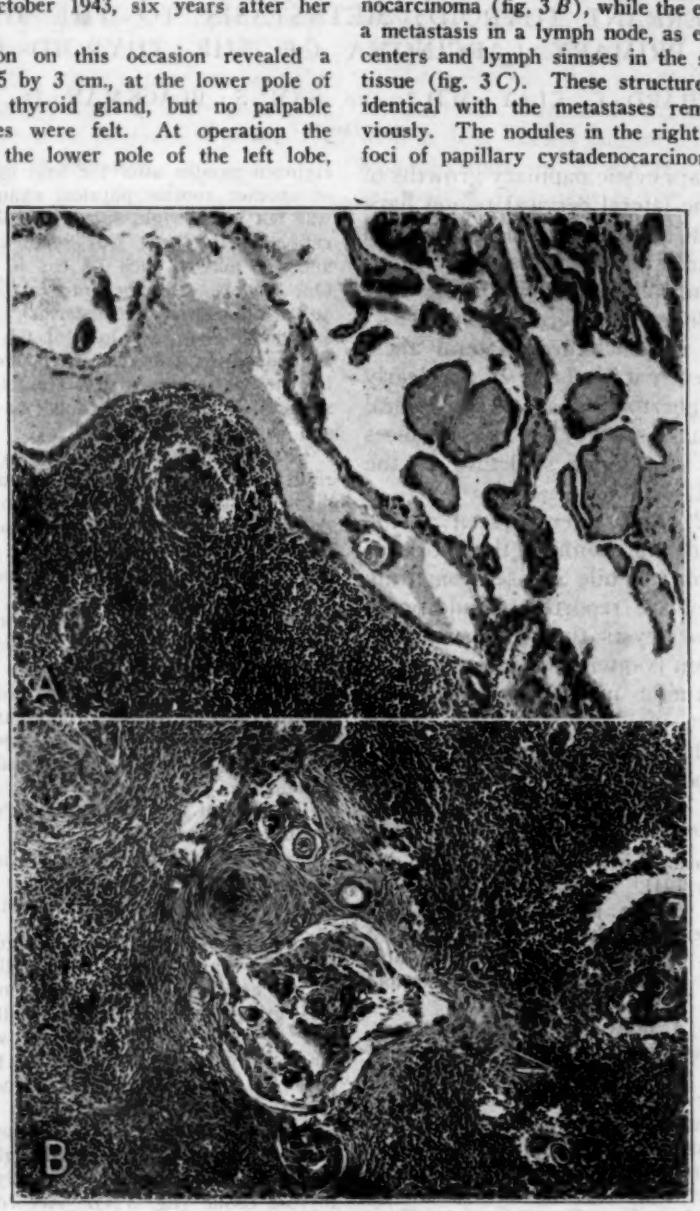

Fig. 1.—*A*, first metastasis of papillary cystadenocarcinoma removed from lateral cervical region in case 1 eighteen months before the primary tumor in the thyroid was suspected. Remnants of the largely destroyed lymph node in which the metastasis lies can be seen here. *B*, another area from the section seen in *A*, showing undifferentiated tumor and small foci of calcification in the lymph node.

and a subtotal bilateral thyroidectomy was done. Further exploration of the neck and superior mediastinum revealed a single, encapsulated, soft, brownish nodule, 2 cm. in diameter, lying posterior to the lower pole of the left lobe between the esophagus and the carotid vessels, but completely detached from the thyroid gland. The nodule was removed, and no other masses were found.

Examination of the specimens showed that, in addition to the mass disclosed at operation in the left lobe

In this case, then, the primary carcinoma was not palpable in the exposed thyroid at the time of removal of the first metastases, and only five years later became noticeable to the patient. Meanwhile a metastasis developed which was apparently not present at the first operation, was not felt on physical examination at the time of the second, and was discovered only by surgical exploration of the neck.

The patient's lungs and mediastinum show no evidence of metastases on roentgen examination at the

time of writing; of course, with such slowly growing tumors this fact is of limited significance. She is to receive irradiation of the cervical region.

COMMENT

The suggestion that carcinoma in so-called lateral aberrant thyroids might actually represent metastasis from a primary tumor in the thyroid originated with Wohl.[3] He reported a case of a 19 year old woman who had five lateral cervical nodules, of which two showed "papillary adenocarcinoma" while the other three revealed metastases of the same tumor in lymph nodes. The patient had "a very adherent, indurated and slightly enlarged thyroid gland, probably carcinomatous," but biopsy was not performed. This author concluded that carcinomatous thyroid tissue in the lateral aspect of the neck might not be primary in lateral aberrant thyroid but metastatic from the thyroid itself.

Eberts[4] was even more specific. Having seen 2 patients with "lateral aberrant thyroid tissue" who subsequently had "massive malignant disease in the homolateral lobe" of the thyroid, when he again encountered a malignant papillary adenoma of "aberrant thyroid" associated with several metastatic lymph nodes he explored the corresponding lobe of the thyroid. Finding it normal to palpation, he freed the lobe and encountered on the posterior surface a previously impalpable nodule "the size of a split pea" which microscopically had the same structure as the lateral metastases. He pointed out that the direc-

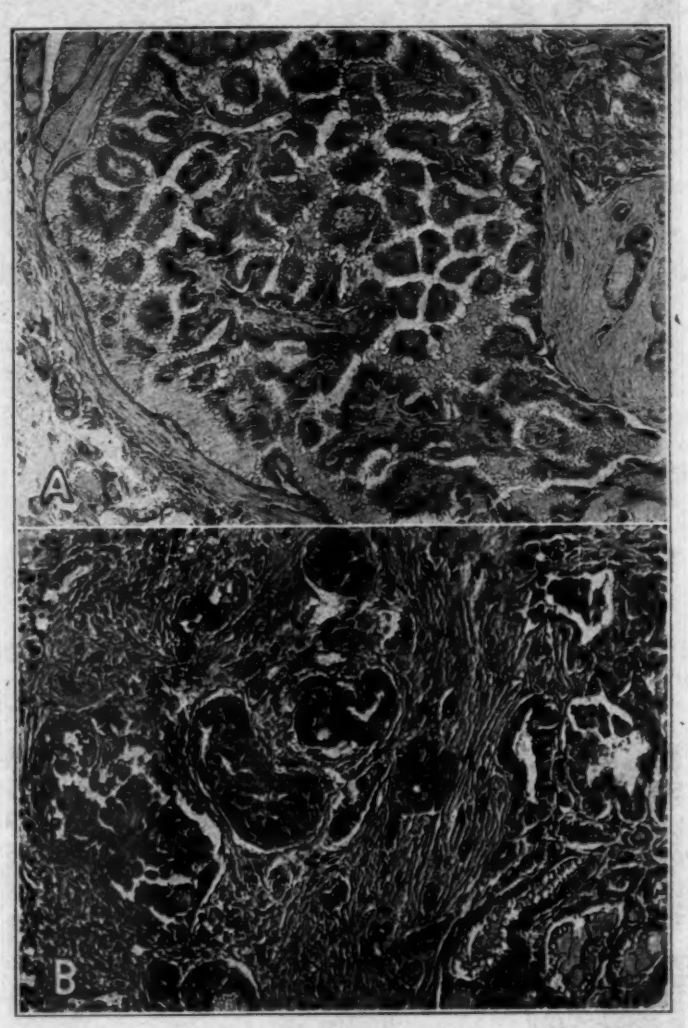

Fig. 2.—*A*, a focus of papillary cystadenocarcinoma from the right lobe of the thyroid in case 1. On purely histologic grounds this focus would be thought benign. *B*, an area of undifferentiated carcinoma from the right lobe of the thyroid in case 1.

3. Wohl, M. G.: Carcinoma of Lateral Aberrant Thyroid, Interstate M. J. **24**:1044, 1917.

4. Eberts, E. M.: Lateral Cervical Aberrant Thyroid, Canad. M. A. J. **29**:32, 1933.

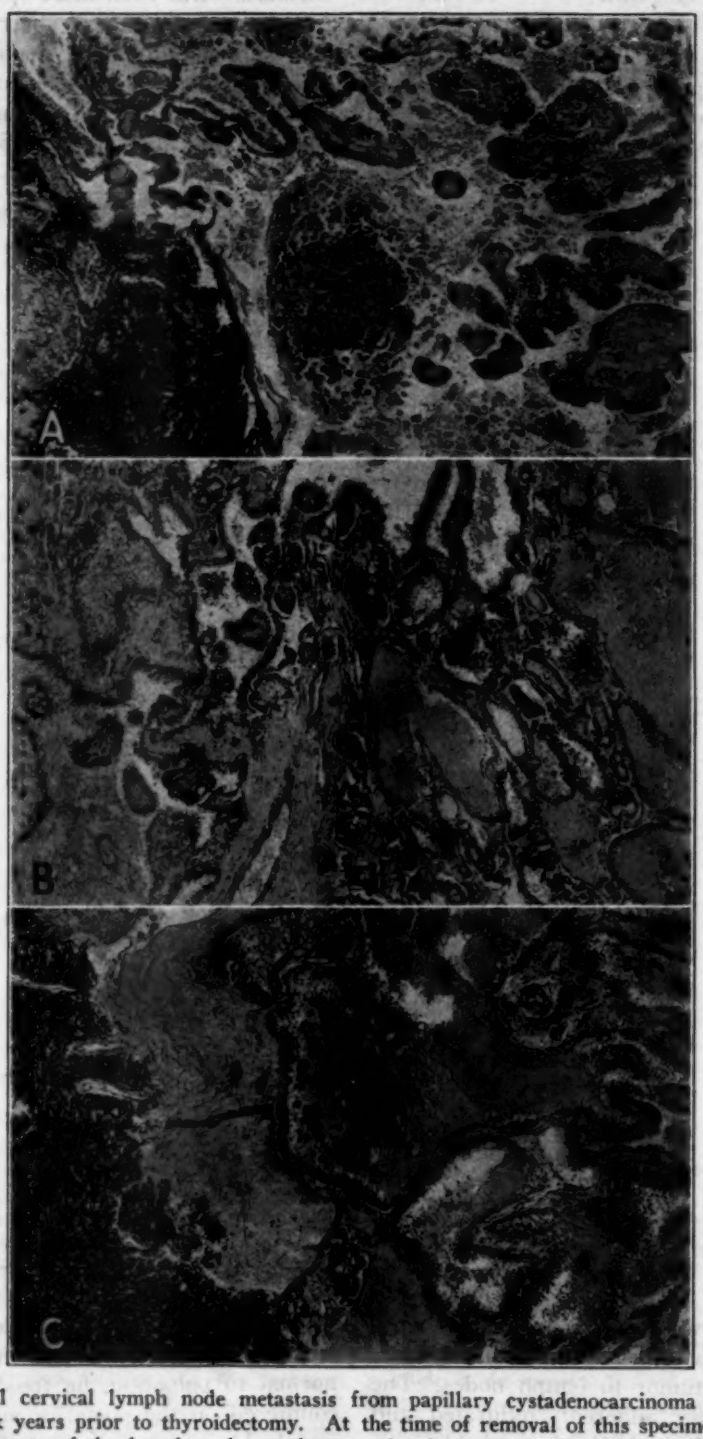

Fig. 3.—*A*, lateral cervical lymph node metastasis from papillary cystadenocarcinoma of the thyroid gland in case 2 removed six years prior to thyroidectomy. At the time of removal of this specimen, no primary tumor was suspected. Remnants of the lymph node can be seen in the section. *B*, primary papillary cystadenocarcinoma from the left lobe of the thyroid in case 2. This tumor is identical with the previously removed metastasis seen in *A*. *C*, lymph node metastasis from papillary cystadenocarcinoma of the left lobe of the thyroid seen in *B*. This specimen lay detached from the thyroid, posterior to the lower pole, between the esophagus and the carotid vessels.

tion of lymph flow was away from the thyroid and toward the cervical nodes and that, as with certain other carcinomas, metastatic lesions sometimes outgrew the primary one. He concluded that "palpation, if negative, should be followed by exploration of the lobe."

Subsequently Pemberton [5] stated in the course of general discussions on carcinoma of the thyroid that he believed papillary adenocarcinoma of so-called lateral aberrant thyroids was primary in the thyroid itself.

Frantz, Forsythe, Hanford and Rogers [6] analyzed 30 cases of "lateral aberrant thyroid," interpreting 23 as malignant on histologic grounds. One of their alleged benign lesions, however, was stated to be in a lymph node, and, as our case 2 indicated, histologic criteria of benignancy of these lateral thyroid tumors is unreliable. Of these 23 patients, 16 had primary carcinoma in the thyroid gland, 1 had an "adenoma" not further described, and in 6 the thyroid was not removed because it seemed normal to the surgeon. In 7 cases some of the lateral cervical nodules removed were recognized as being metastases in lymph nodes from carcinoma of the thyroid. The data point inescapably to the fact that these tumors were primary in the thyroid, while the lateral masses represented metastases to the lymph nodes, although this point was not made by the authors. Among the 23 patients with malignant lateral cervical masses, 5 were known to have distant metastases, 1 having died five months after operation, 2 others having survived for eight and nine years postoperatively and another having died of intercurrent disease sixteen months after operation, while the fifth, operated on three years before the paper was written, was alive at that time.

Touroff [7] has recently reported the case of a patient who had multiple lateral cervical nodules, one of which was found by biopsy to be papillary thyroid tissue. The nodules were subsequently removed along with the homolateral thyroid lobe, which was seen at operation to be enlarged 50 per cent due to a small discrete tumor. This tumor and the lateral cervical nodules all contained papillary thyroid carcinoma, and several of the lateral masses were recognized as lymph nodes containing metastatic thyroid tumor. The cervical nodules which failed to reveal lymph nodes around the tumor were interpreted as aberrant thyroid, but there is no indication that multiple sections were made to ascertain whether recognizable lymph node was present at other points in the nodules. This case was interpreted as representing coexisting identical carcinomas of the thyroid gland and aberrant thyroid tissue, with metastases in cervical lymph nodes. An alternative explanation is that the tumor of the thyroid gland was primary while the lateral masses were all metastases in cervical lymph nodes.

King and Pemberton [2] have recently made clear that the relation between the "lateral aberrant thyroid" and the thyroid gland is that of metastasis and primary carcinoma. They reported 51 cases of malignant "aberrant thyroid" lesions in the lateral cervical regions, of which 31 were associated with carcinoma of the homolateral thyroid lobe, established by microscopic examination, inoperability or death. No microscopic examination of the other 20 thyroid glands was made. In 19 instances specimens of the thyroid gland and the lateral cervical mass were obtained and were found to be identical. Ten of the patients died of carcinoma of the thyroid gland, though 1 lived nineteen years postoperatively and another lived nine and one-half years after pulmonary metastases were demonstrated.

These authors also report 15 cases in which the diagnosis was conceded to be papillary carcinoma of the thyroid with metastases to cervical lymph nodes to show that they differ from the first series only in "relative degree of prominence of the clinical history and findings of the 'aberrant' or thyroid tumor." Even among these cases the primary carcinoma of the thyroid was found only at operation in 4 instances, while in 3 others the surgeon removed what he thought was a normal thyroid lobe only to have the pathologist find in it a small papillary carcinoma identical with the metastases. In 60 per cent of the cases of this series the lateral metastases contained lymphoid tissue, the same proportion which contained such tissue in the first group of 51 cases. The authors conclude that "aberrant" thyroid tumors are not adequately treated until the homolateral lobe of the thyroid has been removed, whether or not a gross tumor is evident at operation.

The microscopic appearance of these cystic papillary tumors is not a reliable index of their malignancy (ability to metastasize). In 1 of the cases described in this paper, neither the primary tumor nor any of the metastases showed microscopic evidence of anaplasia. The tissue was cystic and papillary in pattern, there were no

5. Pemberton, J. de J.: Treatment of Carcinoma of the Thyroid Gland, Ann. Surg. **100**:906, 1934; Malignant Lesions of the Thyroid Gland, Surg., Gynec. & Obst. **69**:417, 1939.

6. Frantz, V. K.; Forsythe, R.; Hanford, J. M., and Rogers, W. M.: Lateral Aberrant Thyroids, Ann. Surg. **115**:161, 1942.

7. Touroff, A. S. W.: Coexisting Carcinomata of Thyroid and Aberrant Thyroid with Regional Metastases, Ann. Surg. **113**:73, 1941.

mitotic figures, and there was little or no variety in the shape, size or chromatin content of the nuclei. The tumors in this case resembled exactly those which are usually described as papillary cystadenoma of the thyroid gland.

In the other case the primary tumor in the thyroid and the cervical metastases contained cells arranged in a variety of patterns. There were cystic and papillary areas, foci whose cells formed large acini full of colloid and small solid strands and masses of undifferentiated cells without any definite architecture. The cells arranged in these three ways showed little or no evidence of anaplasia.

Some authors,[8] recognizing the frequent coexistence of "lateral aberrant thyroid" carcinoma with carcinoma in the thyroid itself, have interpreted the lateral mass as the primary tumor and the thyroid lesion as metastatic. Aside from the fact that such a route of metastasis is counter to the direction of lymph flow, such an interpretation is tenable only if it can be incontrovertibly shown that the lateral lesion is not a metastasis in a lymph node. Since a growing metastasis from a tumor destroys the node in which it lies, random sections of such a lateral cervical mass might well fail to show the architecture of the residual lymph node. In the cases reported in the literature the presence of lymphoid tissue in the lateral cervical masses is frequently noted, but there is no report of a careful search by multiple sections for the remains of a lymph node in the other cases. Until evidence is adduced to show cases in which such careful study of the lateral lesions fails to reveal remnants of lymph nodes and also in which the excised thyroid gland on thorough search reveals no carcinoma, the interpretation of the lateral lesions as primary and any concomitantly occurring lesions in the thyroid gland as metastatic cannot be proved. Such evidence is lacking. On the other hand, the 2 cases presented here in each of which the lateral masses were in lymph nodes and a similar tumor was found in the thyroid, together with the fact that in every case of King and Pemberton in which the thyroid was removed a tumor histologically identical with those in the lateral masses was found in the gland itself, point to the explanation that the tumor in the thyroid is primary and the lateral masses metastatic.

8. Lahey, F. H.; Hare, H. F., and Warren, S.: Carcinoma of the Thyroid, Ann. Surg. **112**:977, 1940.

SUMMARY

Two examples of the condition which has repeatedly been described in the medical literature during the past forty years as "lateral aberrant cervical thyroid" have been studied. In both cases the lateral cervical masses were found to be metastases in lymph nodes, while the primary tumor in each case was found in the homolateral lobe of the thyroid gland.

In one case the primary tumor was palpable only at operation, nineteen months after removal of the first metastases in cervical lymph nodes. In the other case three cervical metastases were removed at a time when no tumor was recognized in the exposed thyroid at operation. Six years later, however, another cervical metastasis was found, and the primary tumor in the homolateral lobe of the thyroid was then about 4 cm. in diameter. In this case there were small foci of papillary cystadenocarcinoma in the opposite lobe of the thyroid as well.

CONCLUSIONS

Evidence from the literature and from 2 additional cases indicates that the lesions long known as lateral aberrant cervical thyroid should be interpreted, until satisfactory evidence to the contrary is adduced, as tumor metastases in cervical lymph nodes from small primary carcinomas in the homolateral lobe of the thyroid. When such a lesion is found in the lateral cervical region, the thyroid should be explored and at least the homolateral lobe should be removed, whether the primary tumor is palpable or not. The tumor may be present in both lobes of the thyroid, and if only one lobe is removed the patient should be watched for the subsequent appearance of lesions in the opposite lobe.

The spread of metastases to lungs, bones and other sites may be relatively slow, and this particular tumor seems therefore to represent one type of carcinoma in which there is reason to believe that the disease may be cured by surgical removal of the primary lesion and the first metastases.

The microscopic appearance of these tumors is not a good index of malignancy since metastases develop which look histologically "benign."

Johns Hopkins Hospital.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1942

A REVIEW PREPARED BY AN EDITORIAL BOARD OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

(Concluded from page 184)

XIX. FRACTURES

A. FRACTURES EXCEPTING FRACTURES OF THE NECK OF THE FEMUR

PREPARED BY H. EARLE CONWELL, M.D.; HERMAN F. JOHNSON, M.D.; DON H. O'DONOGHUE, M.D.; WALTER G. STUCK, M.D., AND EUGENE M. REGEN, M.D.

Fractures of the Clavicle.—Hodgson [489] reports a method for treatment of certain fractures of the clavicle which do not respond to ordinary methods or for which ordinary methods are contraindicated. The usual figure-of-eight bandage is applied to hold the shoulders back. The patient is then placed in bed with the head of the bed elevated, and a muslin bandage is passed through the figure-of-eight bandage on the affected side and around the head of the bed. The weight of the body slipping toward the foot of the bed maintains constant traction of the shoulder upward and outward. Hodgson states that this will reduce practically any fracture of the clavicle. It is necessary to keep the patient in bed, on the back, with a small pillow between the shoulder blades, for three to five weeks, until union is secure.

[ED. NOTE.—While this method will undoubtedly maintain reduction in the majority of instances, it entails the disadvantage of keeping the patient in bed in one position for several weeks. It would seem that this treatment should be reserved for selected cases or used only as a method of reducing the fracture and followed by a fixation dressing which will permit the patient to be ambulatory.]

Slaughter [490] reports on 5 patients with pathologic fractures of the clavicle and 3 patients with pathologic fractures of the ribs. All were persons who had been treated with radiation for carcinoma of the breast. There was no evidence of metastasis. All the fractures occurred during normal activity of the patients. Only 3 of the 8 patients were aware of the fracture; the lesions of the others were discovered in a routine check-up examination. The author points out that bone may be profoundly affected in the clinical use of radiation. He attributes this to two factors: (1) Bone absorbs more energy from radiation per unit of volume than any other tissue, and (2) because of the high calcium content of bone greatly increased secondary radiation is produced. He believes that massive doses of radiation will cause more damage to bone than fractional irradiation with the same total dose, since bone makes almost complete recovery from light doses but with heavy doses may undergo necrosis. In this stage there is no repair and the bone becomes a sterile foreign body. He warns against placing radium or radon near bone when it is used in interstitial irradiation.

Fractures of the Humerus.—For supracondylar fractures of the elbow in children with extreme generalized swelling of the region or in cases in which closed reduction has failed, Hart [491] believes that manipulative reduction and maintenance of acute flexion are contraindicated. He has used 4 to 6 pounds (1.8 to 2.7 Kg.) of skeletal traction with a Kirschner wire through the proximal end of the shaft of the ulna (not through the olecranon process). The line of traction is directed upward and forward in relation to the elbow. Countertraction is obtained by utilizing the weight of the patient's body and by attaching a weight of 1 to 3 pounds (0.5 to 1.5 Kg.) to a padded linen towel and placing the towel over the abducted arm. The entire arm projects beyond the edge of the bed. Elevation of the side of the bed or insertion of sand bags between the mattress and the springs protects the child

489. Hodgson, F. G.: A Treatment for Fractured Clavicle by Traction, South. M. J. **35**:1079-1080 (Dec.) 1942.

490. Slaughter, D. P.: Radiation Osteitis and Fractures Following Irradiation with Report of Five Cases of Fractured Clavicle, Am. J. Roentgenol. **48**:201-212 (Aug.) 1942.

491. Hart, V. L.: Reduction of Supracondylar Fractures in Children, Surgery **11**:33-37 (Jan.) 1942.

from falling out of bed. [Ed. Note (L. D. B.).—Too careful watch cannot be maintained if countertraction is applied by a weight suspended over the abducted arm, as palsy of the radial nerve may develop in a surprisingly short time. In many cases the same force can be obtained by cutaneous traction to the forearm. Sides to the bed with the arm extending through the side can be used for countertraction provided the posts are well padded.]

Winfield, Miller and LaFerte [492] believe that the "hanging cast" method of treatment of fractures of the humerus is most effective. They point out that it does not depart from established principles as widely as is generally supposed, as it is one of the best examples of the use of traction. The muscles of the arm are relaxed when the arm is hanging at the side; so the deltoid muscle does not displace the fragments. They use a pad on the inner side of the cast at the bend of the elbow if a fracture of the middle or lower third of the humerus has a tendency to assume a varus position. Manipulation is used, as it has been found that the traction cast will produce excellent functional and satisfactory anatomic results. Care must be taken not to use too heavy a cast, since distraction may be produced, particularly with transverse fractures. One hundred and three cases are reviewed. The average time the cast was worn was forty-seven and one-half days. In summary, this method is applicable to most fractures of the humerus; the cast is cheap, simple and easy to apply; it is comfortable; it permits ambulation of the patient and allows early mobilization of the joints; the period of hospitalization and the amount of physical therapy required are reduced to a minimum; the incidence of delayed union and of nonunion is low, and the end results are equal to or better than those obtained by other methods. [Ed. Note (L. D. B.).—This detailed analysis of such a large number of cases helps to establish the use of the hanging cast as the standard treatment for fractures of the humerus.]

Breck and Basom [493] employ a posterior molded plaster splint for simple fractures of the shaft of the humerus without displacement, after closed and open reductions and after bone graft operations. The splint extends from a point just lateral to the base of the neck, over the point of the shoulder and then posterolaterally over the upper part of the arm, elbow and forearm to the middle of the hand, leaving the fingers free. The arm hangs by the side with the elbow at a right angle and the wrist straight. A generous pad of sheet wadding is placed in the axilla and a small pad in the antecubital fold. The splint is held in place with gauze roller bandage, and when the plaster has set woven elastic bandages are applied over the gauze bandage. The arm is then placed in a sling, and another circular piece of muslin encircles the upper part of the arm and the body, pinning the arm to the body. A special harness-like piece of apparatus, made of duck with adjustable straps and buckles, is then applied. [Ed. Note (L. D. B.).—Recent reports indicate that an attempt to produce fixation of the shoulder joint is not necessary in treating fractures of the humerus. It appears that the hanging cast with circumduction exercises for the shoulder is the treatment of choice.]

Stuck and Hinchey [494] review 129 cases of fracture of the shaft of the humerus as regards the form of treatment and the end results. The hanging cast treatment (19 cases) gave the best results. Union was more rapid and no nonunion occurred. The other methods were: abduction splints or casts (57 cases) delayed or nonunion in 9 cases; lateral traction in bed (23 cases) delayed or nonunion 1 case; open reduction was necessary in only 9 cases, or 7 per cent. [Ed. Note (L. D. B.).—This is an excellent review.]

Fractures About the Elbow.—MacAusland [495] gives the advantages of use of a longitudinal screw or nail over that of absorbable suture in the treatment of fractures

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492. Winfield, J. M.; Miller, H., and LaFerte, A. D.: Evaluation of "Hanging Cast" as Method of Treating Fractures of Humerus, Am. J. Surg. **55**:228-249 (Feb.) 1942.

493. Breck, L. W., and Basom, W. C.: A Modified Moulded Splint for Fractures of the Shaft of the Humerus, South. Surgeon **11**:410-413 (June) 1942.

494. Stuck, W. G., and Hinchey, J. J.: Fractures of the Shaft of the Humerus, South. Surgeon **11**:305-315 (May) 1942.

495. MacAusland, W. R.: The Treatment of Fractures of the Olecranon by Longitudinal Screw or Nail Fixation, Ann. Surg. **116**:293-296 (Aug.) 1942.

of the olecranon as: (1) better reduction, (2) better retention, (3) shorter disability and (4) motion in four to five days, against four to five weeks with the use of suture. He points out that effective treatment depends on two factors: accurate anatomic reposition of fragments and sufficient fixation. He uses a screw of sufficient length to engage the cortex of the distal fragment. Exercises of the fingers and shoulder are started on the second day to preserve the tonicity of the muscles. Gentle motion of the elbow in flexion and extension can usually be started on the fourth or fifth day. Removal of the screw or nail in six months is optional. [ED. NOTE (L. D. B.).—The author has discussed one of the better methods of treating olecranon fractures. It should be remembered that frequently no definite choice can be made as to the method of treatment. If the proximal fragment is small excision does not interfere with function of the elbow and aids early recovery.]

Observation of over 1,000 cases of fracture about the elbow led Conwell [496] to several conclusions: In manipulation of supracondylar fractures, if there is no displacement the elbow should be flexed and this position maintained. Flexion will be free when reduction is complete unless limited by swelling. The degree of flexion for immobilization of the forearm varies inversely with the swelling. It is extremely important to watch the circulation in any case of injury of the elbow. Traction should be applied to the forearm, keeping it in full extension with elevation to 45 degrees, when much swelling is present. Aspiration of the hematoma, or even incision and drainage, may be necessary. Ischemic paralysis or even gangrene may result if too acute flexion is used. Skeletal traction is important in the treatment of compound fractures of the lower end of the humerus. The author advocates use of sulfanilamide as well as of sulfathiazole in treating these wounds.

A fracture of one of the condyles, if the fragment is displaced, usually requires open reduction. If the fragment is large in a fracture of the capitellum, it may be reduced by direct pressure while the forearm is adducted and slightly flexed. If reduction is impossible, arthrotomy is indicated for reduction or removal of the fragment. A fracture of the olecranon in which there is separation of the fragments requires open reduction and fixation by stainless steel wire. Motion should be started in seven to ten days.

Fractures of the head and neck of the radius are found to occur rather frequently since the increased use of roentgen rays, not only as isolated injuries but with other injuries of the elbow. Operative treatment is advocated if as much as one third of the head is broken off and displaced. Displacement interferes with free motion of the elbow. If the fragment is small, the surgeon is justified in waiting to see how much limitation of motion results before operating.

Dislocations of the elbow are next in frequency to those of the shoulder, posterior displacement being more common. A definite click is felt in reducing these, after which there is little or no resistance in flexion. One should immobilize in as much flexion as is safe according to the swelling present. Flexion should be maintained by a posterior plaster splint for ten to fourteen days, with gradual extension thereafter.

Lee [497] contends that the serviceable elbows which result after fracture of the humeral condyles in children are due to the reparative power of the children rather than to good treatment of the fractures. An analysis of 32 cases is presented, with a report of the end results. Some of the patients were seen twenty-two years after the injury. Although equally good results were seen to have been produced by open and by closed methods, there was marked difference in the end result roentgenograms. Malunion and overgrowth of the condyles were evident in the patients treated by a closed method, while those treated operatively showed accurately replaced and well developed condyles. Slight limitation of motion in the elbow may be disregarded by both the patient and the physician, as the joint bears no

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496. Conwell, H. E.: Fractures About Elbow Joint Especially in Children, Nebraska M. J. **27**:229-232 (July) 1942.

497. Lee, H. G.: Fractures of the Humeral Condyles in Children, Surg., Gynec. & Obst. **75**:97-102 (July) 1942.

weight and its useful range is 60 degrees of flexion to 130 degrees of extension. The author suggests chromic catgut or a vitallium nail for fixation of the fragment in open reduction. Solid healing should be allowed before motion is started. Forcing the joint causes further damage. Motion will return with use provided there is no bony block or formation of scar tissue.

Neuwirth [498] has treated a series of fractures of the elbow joint by the nonsplinting method, because so many poor functional results have occurred with splinting and because small fragments near a joint are difficult to control by external splinting even when accurate reduction has been accomplished. The arms of the patients treated without splinting were placed in triangular bandages suspended from the neck, with the elbows flexed. Movement of the elbow joint as well as of the arm was encouraged as soon as pain had subsided. A group of 5 cases is presented, in which all the patients regained 100 per cent function. Neuwirth contends that the nonsplinting method of treatment should be the rule and fixation and splinting the exception.

After a review of the literature and of the end results in 16 cases of fracture of the head of the radius in children, Roosvall [499] draws the following conclusions: 1. Fractures without or with only moderate displacement (to an angle of 45 degrees) should be treated conservatively. 2. Reduction by manipulation can be used also for severe fractures, yielding good ultimate results. 3. In cases of greater displacement of fragments, in which reduction by manipulation has failed, early operative reduction is to be preferred to extirpation of the displaced fragments. 4. In the case of extirpation, synostosis between the radius and the ulna occurs to a great extent, and sometimes also reduction of flexion and extension in the elbow. 5. In the cases in which the fragment has been removed one also gets a fairly pronounced valgus formation in the elbow as a result of removal of the epiphysis with consequent impaired growth. A tabular analysis of the 16 cases is presented. Open reduction was done in 3 cases. In 4 cases extirpation was done owing to the marked displacement of the upper fragment. Nine patients were treated conservatively. Of these, 5 were free from subjective symptoms. In 8 the configuration of the elbow was normal, and in 6 function was normal. Good results were obtained in all except 1 case, in which rotation was impossible owing to bony synostosis between the radius and the ulna. Of the 3 patients treated by open reduction who were followed up, all were free from subjective symptoms. In 1 case there was normal mobility. [Ed. Note (L. D. B.).—This report is a warning against too early and too radical operation for fractures of the head of the radius.]

Cohn [500] reviews fractures of the elbow and points out the dangers of loss of motion unless reduction is accomplished. In the diagnosis, careful clinical examination should be performed. Roentgen examination alone can give a false sense of security, especially in cases of fractures in children. It is essential to know the date of appearance, the relationship of and the age of complete ossification of the epiphyses in children if roentgenograms are to be interpreted properly. The capitellum is the only epiphysis which is apparent prior to the fifth year. A common source of confusion is the appearance of the epiphysis for the olecranon. It sometimes ossifies through two separate centers, but more often through a single center, with ossification proceeding from the tip down. Not uncommonly one will find a report of a fracture which does not exist. Excess callus formation developing later in untreated patients may impair motion of the joint.

Operation about the elbow involving the epiphyses should be avoided if possible in children. If a fracture of the internal epicondyle epiphysis cannot be completely reduced, removal of this epiphysis does not cause disturbance of function of the elbow. Every effort should be made to avoid the development of Volkmann's ischemia. When it develops, fasciotomy is indicated, but exposure of the arteries

498. Neuwirth, A. A.: Nonsplinting Treatment of Fractures of Elbow Joint, J. A. M. A. **118**:971-972 (March 21) 1942.

499. Roosvall, A.: Fractures of Neck of Radius in Children, Acta chir. Scandinav. **85**: 540-556, 1941.

500. Cohn, I.: Fractures of Elbow, Am. J. Surg. **55**:210-227 (Feb.) 1942.

is not recommended. Fractures of the head of the radius with displacement usually require resection, and the author describes a method of operative exposure. Operation is indicated in many cases of fractures of the upper third of the ulna, to avoid angulation of the proximal fragment and the resultant partial ankylosis.

For severe comminuted supracondylar fractures in which multiple fragments are present, skeletal traction by means of a Kirschner wire in the upper portion of the ulna just below the olecranon is the best method. If there are not too many fragments and reduction is not accomplished, an operation employing the approach through a trap door in the triceps tendon advocated by Van Gorder with the use of screws and plates is indicated. Many forms of physical therapy and passive motion are dangerous in the postreduction care of the patients. Heat, gentle massage and active motion are the most important procedures to be adopted.

Anderson [501] describes the mechanics of "nursemaid's elbow" as a sudden pull on the extended elbow of a small child which causes anterior dislocation of the head of the radius followed by pain and disability of the arm. The dislocation is slight and can be detected only by roentgen examination of both elbows. Forcible supination while the elbow is bent usually reduces the displacement, and this is often accompanied by a definite click. It is believed that the infantile radial head is pulled through the orbicular ligament, since in early childhood there is not a definite radial head to resist this pull. There is no definite ligamentous tear; hence symptoms are relieved immediately after reduction.

Fractures of the Forearm.—Blount, Schaefer and Johnson [502] give a rather comprehensive discussion of fractures of the forearm in children under 12 years of age and make a plea for conservative management, with the statement that open reduction for fractured forearms of children is difficult to justify. They present several cases of excellent functional results in fractures in which there was fair alinement but unusually pronounced lack of apposition. In conclusion they give the following summary: "(1) Fractures of the forearm in children are different from those in adults and should be differently treated. (2) There is a definite hazard associated with open reduction of fractures of the forearm in children. (3) Except at the elbow, open reduction of fractures of the forearm is difficult to justify in children. (4) Greenstick fractures of the middle third should be reduced by completing the fracture in the interest of maintaining alinement. (5) The radial head should never be removed in a child. (6) If conservatively treated, most epiphysial fractures of the distal end of the radius will heal without disability." [ED. NOTE.—This is an interesting discussion of an ever present problem. The fact that alinement and apposition do not necessarily have to be perfect should not be used as an excuse for poor treatment of these fractures. In the experience of some open reduction when indicated in the markedly displaced fractures has not given the disastrous results reported by the authors.]

Fractures of the Lower End of the Radius and Ulna.—Darrach [503] surveys all the features of the problem of fractures of the wrist and discusses the anatomy, pathology, diagnosis and treatment. For comminuted fractures of the lower end of the radius he advises placing one wire through the base of the second, third and fourth metacarpals and another wire through the ulna just distal to the coronoid. After traction has been applied and the fracture reduced, both wires are incorporated in a plaster cast. [ED. NOTE.—This is an excellent brief summary of the subject.]

Sever [504] studied 199 cases of Colles' fracture roentgenologically before and after reduction. Measurements of the degree of dorsal or volar angulation of the distal fragments were made. The group included simple fracture with little or no displacement to severe comminuted fracture with considerable displacement. In 36 cases the angulation was reduced to 90 degrees; in 24 cases there was an average

501. Anderson, S. A., Jr.: Subluxation of Head of Radius: Pediatric Condition, South. M. J. **35**:286-289 (March) 1942.

502. Blount, W. P.; Schaefer, A. A., and Johnson, J. H.: Fractures of the Forearm in Children, J. A. M. A. **120**:111-116 (Sept. 12) 1942.

503 Darrach, W.: Colles' Fracture, New England J. Med. **226**:594-596 (April 9) 1942.

504. Sever, J. W.: Colles' Fracture: A Study of X-Ray Films Before and After Reduction, New England J. Med. **226**:790-794 (May 14) 1942.

residual deformity after reduction of —8.3 degrees. Thus in 60 cases, or 39 per cent, the reduction was not satisfactory according to roentgenologic standards. In 92 other cases the average postreduction angle was plus 10.9 degrees. Individual values varied from + 5 to + 30 degrees. In cases in which the reduction was performed by a surgeon of experience and skill, generally an excellent anatomic result was found. The author makes a plea for more perfect reductions, correcting dorsal displacement and radial deviation, and for more careful preoperative and postoperative roentgenologic interpretation, including angular measurements.

Ruhlin [505] discusses in detail the etiology and pathology of the condition which most commonly occurs in association with fractures of the lower end of the forearm and is probably due to rupture of the radioulnar triangular ligaments, which permits the lower end of the ulna to separate from the lower end of the radius and cause a disfiguring deformity with occasionally pain and dysfunction. He mentioned no less than twelve different operative technics, stating that each operator seemed to have his own technic, there being no standard accepted method for open fixation. The plan for operation is essentially either to obtain solid union between the radius and the ulna at the distal end, with or without resection of the ulna above the point of union, or, secondly, to obtain fixation by some type of fascial sling or loop between the ulna and the radius. Results are not uniformly good, and operation should be reserved for patients with a high degree of disability and pain. Nine cases were recorded at the University of Iowa Hospital; 4 of the patients came to operation and the other 5 responded to conservative treatment, consisting of fixation by a wristlet and physical therapy. [ED. NOTE.—It would appear obvious from the multitude of operative plans suggested that none of them are entirely satisfactory. The author does not mention the fact that the radius is often foreshortened and there is actually a comparative lengthening of the shaft of the ulna which will require resection of some portion of the ulna in order to restore a normal relationship in length between the radius and the ulna. This condition is much more common than the reports in the literature would seem to indicate. We have had 3 successful results with fascial transplants, modified Eliason technic.]

Milch [506] gives a logical and comprehensive discussion of a so-called dislocation of the lower end of the ulna. He points out that the name of the deformity is a misnomer; that the ulna is the fixed point of the wrist to which the carpus and radius are attached by the ligaments of the wrist joint. He includes a whole group of conditions which have a wide variety of causes which will require similar variety in treatment. Prominence of the head of the ulna may be caused by (1) the triangular fibrocartilage, (2) the ulnar collateral ligament, (3) rupture of the radioulnar ligaments, (4) actual deformity of the bones of the forearm, (5) disproportion in length of the bones of the forearm and (6) enlargement of the ulnar head itself. From the standpoint of treatment, types 1, 2 and 3 are classified together as due to injuries of a ligament and are best treated by repair of the involved or damaged ligament. In early stages this can be done by operation on the ligament itself, and later the fascial loop operation is the treatment of choice. The author emphasizes that if the condition is caused by actual deformity of the osseous structures, in either actual deviation of either bone of the forearm or disproportion in length of the bones, or by disease of the ulnar head, it is imperative that the bony deformity be corrected before any repair of ligaments is attempted. Repair of ligaments can result only in failure if there is a basic maladjustment between the radius and the ulna. In most cases correction of the bony deformity will in itself correct the condition and repair of a ligament will not become necessary. The author makes a plea for careful study of these conditions to avoid needless sacrifices of the head of the ulna, since repair of ligamentous structures to the intact ulnar head is much more essential in cases in which the condition is caused by damage of a ligament. He emphasizes repeatedly that the lower end of the ulna is the fixed point at the carpus and that sacrifice of this point can result only in imperfect function at best.

505. Ruhlin, C. W.: Subluxation of Distal End of Ulna, J. Maine M. A. **33**:197-200 (Sept.) 1942.

506. Milch, H.: So-Called Dislocation of the Lower End of the Ulna, Ann. Surg. **116**: 282-292 (Aug.) 1942.

[ED. NOTE.—This is an excellent article and merits careful study by any one facing this problem.]

Fractures and Dislocations of the Bones of the Hands and Feet.—Farquharson [507] believes that the main cause of delayed union in fractures of the carpal navicular is shearing strains to which the fracture is subjected by movement at the wrist joint. He has devised a special splint to give continuous immobilization in these fractures. The splint is shaped to the contour of the hand and wrist and consists of a light metal framework with an adjustable band of soft aluminum which encircles the hand and allows free flexion of the fingers. The author states that in the cases in which the splint has been employed progressive union has taken place. [ED. NOTE (L. D. B.).—The author has described a practical splint. The value of the paper is in its warning against incomplete immobilization.]

Fractures of the os triquetrum are believed by Fairbank [508] to be much more common than was previously supposed. Of 11 fractures of this type that were treated, 10 were small chip fractures and 1 was a complete fracture through the middle of the bone without displacement. All were due to a backward fall on the outstretched hand, in 1 instance in volar flexion and in 10 in dorsiflexion. All the patients were soldiers, and their ages varied from 23 to 37 years. Examination showed a stiff, weak, painful wrist with pain, swelling and tenderness over the dorsum of the os triquetrum. Dorsiflexion and ulnar deviation produced pain. On roentgen examination, all were visible in the lateral but invisible in the anteroposterior view. The oblique view is most important, as it shows whether the chip is from the os triquetrum or the lunate bone. No attempt was made at reduction, as the displacement was never pronounced. Four patients were treated by plaster fixation for a time varying from four to ten weeks. The remaining 7 were placed in strappings of elastic adhesive tape (elastoplast) and were back on full duty in one to twenty-eight days, the average being ten days. Union took place in all cases, although in 1 it required twelve months. With the chip fractures, prognosis is excellent and recovery rapid. Immobilization does not seem necessary for bony union. The avulsion fractures are more serious and require longer periods of immobilization. Minor symptoms may persist for many months, but they do not interfere with the activities of the patient.

Ferreyra and Carranza [509] report 8 cases of fracture of the base of the first metacarpal bone and state that the typical Bennett fracture has an oblique direction. They divide the fractures of the base of the first metacarpal into five types, as follows: (1) total extra-articular fracture (transverse or oblique); (2) mixed extra-articular fractures with an intra-articular fragment; (3) articular fractures of the Bennett type; (4) articular fractures of the Rolando type (Y shaped); (5) partial articular fractures which are H shaped and have four fragments, three of them intra-articular. They point out the importance of accurate reduction and state that the purpose of reduction is to avoid limitation of the four fundamental movements of the thumb. They have found that the best results can be obtained when traction is exerted in the direction of a line from the center of the fold in the elbow to the styloid apophysis of the corresponding radius.

Fitte [510] suggests a technic for treatment of semilunar dislocations. Local procaine hydrochloride anesthesia is used, and one-quarter hour later continuous traction is applied to the fingers by means of the Finochetto apparatus with 15 Kg. of weight for ten to fifteen minutes. A roentgenogram is then taken, which may in some cases show that spontaneous reduction has occurred. A plaster cast is applied to maintain the reduction. Good reduction was obtained in all 8 cases by this technic. An improvised traction apparatus is described, for use by physicians

507. Farquharson, E. L.: Splint for Fracture of Carpal Navicular, J. Bone & Joint Surg. **24**:922-924 (Oct.) 1942.

508. Fairbank, T. J.: Chip Fractures of Os Triquetrum (Carpal Cuneiform), Brit. M. J. **2**:310-311 (Sept. 12) 1942.

509. Ordónez Ferreyra, H., and Martínez Carranza, H.: Bennett Fracture: Case, Biol. y trab., Soc. de cir. de Córdoba **2**:263-277, 1941.

510. Fitte, M. J.: Therapy of Luxation of Semilunar Bone and of Second Row of Carpus, Bol. y. trab., Acad. argent. de cir. **26**:534-539 (July 22) 1942.

who do not have the Finochetto appliance. [ED. NOTE.—In isolated dislocations of the semilunar bone one editor (H. E. C.) feels that no technic is superior to early diagnosis followed by early reduction by the thumb pressure and manipulative technic.]

Gebhard [511] describes a method for the treatment of fractures of the metatarsal bones in which no fixation is used. It consists of application of an anterior bar on the shoe, the bar being placed 1½ to 1¾ inches (3.8 to 4.5 cm.) obliquely to the metatarsal heads in front of the heel, the location being determined by having the patient bear weight with the foot in a shoe over a broom handle and the point at which weight bearing is free of pain is where the bar is attached. The bar should be high enough to keep the ball of the foot from reaching the floor. Gebhard states that follow-up roentgenograms revealed uniformly good results. The theory of treatment is that with the bar under the arch of the foot the toes tend to reach for the ground and so arch the metatarsals into normal position. He states that the patients were highly satisfied and that they were able to return to work within a couple of weeks from the time of injury. The method was used in cases in which no more than four metatarsals were broken. [ED. NOTE.—No roentgenograms are shown; no case reports are given, and no contraindications to the method are mentioned. The recommendation of this method would better be supported by roentgenograms and detailed case reports. The author should be urged to present his cases in detail to permit further study of the method.]

Fractures of the Pelvis.—Dewitt [512] reports a case of fracture of the acetabulum with medial displacement of the head of the femur. Perfect reduction was secured by skeletal traction exerted longitudinally and by a lateral pull secured through the use of an eye screw fastened into the greater trochanter. Nevertheless, three years later there were many degenerative changes in the head of the femur, due doubtless to the circulatory damage which accompanied the original injury. [ED. NOTE.—In any case of injury of the hip with dislocation of the head of the femur, it is proper to assume that the nutrition of the head is seriously impaired. Therefore, prolonged protected weight bearing for many months should be a routine recommendation. The author's method of reduction would appear to be more comfortable than most of those generally used.]

Furey [513] reports 96 fractures of the pelvis, resulting for the most part from great violence. Eighty-six involved the region of the obturator ring. Sixty-seven were posterior fractures of the pelvic ring. Close study of the bodies, wings and foramens of the sacrum gave clues leading to the discovery of many of the more obscure fractures. Excellent roentgenograms are essential, and in many cases one has to reexamine the patient carefully in the x-ray department when his condition improves, instead of relying on a portable film, which shows only the obvious fracture of the obturator ring. The literature reveals reports of from 5 to 30 per cent of posterior pelvic fractures. This contrast with the 70 per cent incidence in this series indicates, according to the author, that such fractures are being missed. The large number of fractures of and about the sacrum, occurring mostly as a result of automobile accidents, is undoubtedly due to the tremendous force involved in such accidents. The author believes that closer study of the sacrum and better detail in the roentgenograms will undoubtedly lead to discovery of many more such fractures.

Fractures of the Femur.—Van Gorder [514] reviews the modern treatment of fractures of the femur and proposes the following standard form of treatment: For fractures of the femoral neck, a cannulated Smith-Petersen nail; for intertrochanteric fractures, Russell traction, although operative treatment in competent

511. Gebhard, U. E.: Simple Treatment for Fractured Metatarsals, Indust. Med. **11**:157 (April) 1942.

512. Dewitt, R. F.: Method of Treatment Used in Fracture of Acetabulum, J. Bone & Joint Surg. **24**:690-691 (July) 1942.

513. Furey, W. W.: Fractures of the Pelvis, with Special Reference to Associated Fractures of the Sacrum, Am. J. Roentgenol. **47**:89-96 (Jan.) 1942.

514. Van Gorder, G. W.: Fractures of the Femur, New England J. Med. **226**:526-530 (March 26) 1942.

hands is being used successfully more and more; for low supracondylar fractures, open reduction or, if that is impossible because of comminution of the fragments, skeletal traction from the tibial tubercle through the knee joint in conjunction with use of a Thomas splint and a Pierson attachment; and for fractures of the shaft of the femur, Russell traction for fractures of the upper third and skeletal traction with a Thomas splint and Pierson attachment for fractures of the middle or lower third. Under war conditions, the insertion of fixation pins above and below the site of fracture, reduction of the fragments and incorporation of the pins in a plaster cast or in a Roger-Anderson steel side bar seems to be the most practical form of therapy, since it permits hurried evacuation.

For children up to the age of 6 years, overhead traction with adhesive tape applied to the skin is the method of choice. For children over 6 years, Russell traction or traction with adhesive plaster applied to the skin in a Thomas splint, followed by use of a plaster cast, is recommended. In hospitals fully equipped for operative procedures on all kinds of fractures, where fracture services are established and the treatment of fractures is considered a specialty, open reduction with internal fixation is the ideal form of treatment of all fractures of the femur in adults.

Fractures of the Patella.—Dobbie and Ryerson [515] report 21 cases of complete excision of the patella as treatment for transverse and comminuted fractures, with excellent results. A good summary of the history of treatment of fractures of the patella is contained in the article. Indications for total removal of the patella are all simple fractures with separation of fragments that require open operation and all compound fractures. Either a transverse or a longitudinal incision is employed. After excision of the entire patella the lateral and medial tendinous expansions are sparingly debrided and sutured. Then the central portion at the site of the patellar excision is sutured edge to edge.

Immediately after the operation the patient is encouraged to move freely about in bed, and on the third or fourth day he is allowed out of bed and encouraged to walk, with or without the aid of a cane according to his desires. Between the seventh and the tenth day the wound is dressed for the first time, stitches are removed and all dressings are discarded. Active flexion and extension exercises are begun. By the end of the second week the patient ambulates well without aid of any sort. The patient is then discharged with instructions to do a considerable, increasing amount of walking daily and is encouraged to walk up and down stairs as much as possible. At the end of six to eight weeks he is able to walk long distances, negotiate stairs and in many instances return to laborious work. Of the 16 patients who could be followed, all had excellent results from three to forty-one months later on the basis of the strictest standards. Dynamometer tests of the power of the quadriceps muscle revealed no impairment of muscle power following recovery, and in many cases the dynamometer reading was 3 to 8 pounds (1.5 to 4 Kg.) greater in the affected limb.

Postoperative roentgenograms disclosed some attempt at regeneration of the patella as evidence of calcific shadows. In 1 case, in which the patient died of a pulmonary embolus seven weeks postoperatively, sections showed excellent primary union at the suture line, with proliferation of fibrous tissue and numerous, confluent, glistening, hard areas of young, growing bone.

The authors concluded that complete excision of patellar fragments in those cases of fracture requiring operation is superior to any other treatment, because the operation is simple and less time consuming, convalescence is smoother and more rapid, the periods of hospitalization and disability are appreciably less, earlier and more complete functional recovery is the rule and the late complications of osseous suture are eliminated. In the cases in which the patella was removed the efficiency of the knee was in no way impaired. The range and rapidity of

515. Dobbie, R. P., and Ryerson, S.: Treatment of Fractured Patella by Excision, Am. J. Surg. **55**:339-373 (Feb.) 1942.

movement and the power are in no way inferior to those displayed in the opposite, intact limb. [ED. NOTE.—The results have been observed by one of the editors (L. D. B.). They are excellent. Can equally good results be obtained by excision of the least useful fragment and repair of the soft parts?]

Thomson [516] discusses the three types of treatment of fractures of the patella: (1) restorative treatment; (2) excision of the patella, and (3) removal of loose fragments with plastic repair of the patellar tendon. He collected 554 instances of use of the third type from leading fracture surgeons by the questionnaire method. He advocates the removal of all but a single attached fragment of the patella in either the proximal or the distal pole and suturing of the patellar tendon to this remaining fragment. He believes that the patella is necessary for the mechanical advantage it produces by means of its pully action. He points out that the osseous reparative quality of the patella is poor.

He concludes that the removal of all fragments except one pole of the patella reduces the problem from one in which an effort is made to obtain a union of fragments of bone that have little osteogenic property to one in which only union of soft tissue is involved, without loss of fulcrum stability of the patella or of buffer protection to the exposed condyles of the femur. By accomplishing this, the period and the amount of disability are reduced. [ED. NOTE (L. D. B.).—The author should be commended for the zeal and enthusiasm with which he has undertaken his crusade against mismanagement of this type of fracture.]

Wass and Davies [517] summarize the views of Brooke on excision of the patella for a simple transverse fracture and review the recent literature, showing that the consensus is against adoption of this procedure as a routine measure. Unsatisfactory results were obtained in 8 cases and are described in detail. The incidence of ossification in the quadriceps tendon following the operation is discussed. The authors suggest that the patella should not be excised for simple transverse fractures with separation. Indications for excision of the patella are: comminuted fractures with separation, compound fractures and selected cases of patellofemoral arthritis following malunited fractures. [ED. NOTE.—The ideas presented by the authors coincide with the opinions of most of the editors.]

Fracture of the Tibia.—Mathewson [518] reports on 132 spiral fractures of the tibia, 74 being treated by open reduction under traction in a Bohler frame and application of one stainless steel wire loop. He is opposed to the two pin method of treatment and to plating, because he feels that the incidence of nonunion is greater with these methods. His method consists of inserting a pin in the os calcis and applying longitudinal traction in a Bohler frame with the knee in flexion. Traction is applied to overcome shortening, and any rotary deformity is corrected. The skin in the operative field is then prepared and the leg draped. On exploring the site of fracture, it is almost always possible to obtain a perfect reduction by a simple manipulation in the frame. Drill holes are made at an angle through the fragments in such a way that the upper portion of the loop is in the proximal portion of the distal fragment and the lower end of the loop in the distal end of the proximal fragment. This steel sling thus prevents shortening. A light dressing is applied over the wound, and a long leg nonpadded cast is applied, the leg part being put on while the limb is still in the Bohler frame, with the pin in the os calcis incorporated. The postoperative care consists of immediate motion of the toes and contractions of the quadriceps muscle. In two weeks the cast is removed, the sutures are taken out and a new nonpadded long leg walking cast with a walking iron is applied. The patient is encouraged to bear full weight on the affected limb, within the limits of pain. After six weeks the cast is removed, and usually bony union has occurred. Physical therapy is then started.

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516. Thomson, J. E. M.: Fracture of the Patella Treated by Removal of the Loose Fragments and Plastic Repair of the Tendon, Surg., Gynec. & Obst. **74**:860-866 (April) 1942.

517. Wass, S. H., and Davies, E. R.: Excision of the Patella for Fracture, Guy's Hosp. Rep. **91**:35-57, 1942.

518. Mathewson, C., Jr.: Spiral and Oblique Fractures of the Tibia, Am. J. Surg. **55**: 295-308 (Feb.) 1942.

In the 74 patients treated by open reduction and wiring, all operative wounds healed per primam with the exception of 2. Both were opened and packed with petrolatum gauze, and in both healing was retarded but solid union was present at the end of five months. The average period of immobilization in plaster was from eight to twelve weeks; the average total period of disability, fourteen weeks. Nonunion occurred in 1 patient, a 37 year old woman who was discharged sixty-seven days after operation with "good union" and "good functional results." She returned two years later with nonunion at the site of fracture. After removal of the steel wire and drilling of the site of fracture, prompt healing occurred.

Of the remaining 68 patients treated by close reduction, 11 had nonunion. Three of them had been treated by means of simple casts and 8 by the use of two pins, one above and one below the site of fracture. The author believes that the two pin method often maintains distraction, which is a frequent cause of nonunion. [ED. NOTE (L. D. B.).—The author's opinion as to the distraction caused by the two pin method is in keeping with that of some of the editors. Obtaining union at the end of six weeks after open reduction of a fracture of the shaft of the tibia is unusual.]

Raymond [519] reports a case of avulsion of the tibial tubercle in a 15 year old boy following a severe injury. The avulsed fragment was replaced and anchored with silk sutures. The author states that only a few cases of such a lesion have been reported and that good results can be obtained only by replacing the fragment by operation.

Pease [520] describes the use of beaded wires for lateral traction on spiral and oblique fractures of the tibia, and describes their advantages in certain selected cases. He recommends use of a specially designed lateral bar incorporated in the cast, to which the traction nuts are applied, in order to prevent direct pressure of the nuts against the side of the cast.

Wilson and Cantwell [521] report 89 cases in which fractures of the leg were treated by the use of Steinmann pins through the calcaneus and through the upper end of the tibia. After reduction of the fracture, both pins were incorporated in a plaster cast. Early weight bearing was allowed. [ED. NOTE.—If reduction cannot be maintained otherwise, this method secures fixation. It is hard to see the advantage of using a walking iron a few days after a fracture of the tibia or fibula. No proof exists that this hastens healing, and it would seem likely to cause some change of position of the fragments in the first few weeks even with this relatively secure fixation.]

Gerwig [522] describes an apparatus for maintaining continuous traction for comminuted, spiral or oblique fractures of the tibia and fibula. Countertraction bars are incorporated in the cast, and as a modification of several previously described apparatus traction is applied from the heel through a spring to an extension bar incorporated in the back of the cast. [ED. NOTE.—The apparatus seems to be entirely satisfactory for this type of fixation. It is particularly emphasized that the patient is not confined to bed and has a considerable degree of mobility. Treatment by this method is extremely limited, since most orthopedic surgeons agree that some type of fixed traction is more efficient and comfortable and gives better immobilization with the average compound fractures.]

Child [523] describes in great detail the development of gangrene in the lower extremities following fracture of both bones of the leg, which had had a severe contusion of the soft tissue. He reviews the literature and finds that only 40

519. Raymond, S. W.: Avulsion Fracture of Tibial Tubercle, Illinois M. J. **81**:476-477 (June) 1942.

520. Pease, C. N.: Beaded Wires in Closed Reduction in Fractures of Leg, Surg., Gynec. & Obst. **75**:647-651 (Nov.) 1942.

521. Wilson, M. J., and Cantwell, A. R.: Double Pin Method in Treatment of Fracture of Tibia and Fibula, Am. J. Surg. **56**:445-447 (May) 1942.

522. Gerwig, W. H., Jr.: Mobile Skeletal Traction for Severe Leg Injuries, Mil. Surgeon **91**:213-217 (Aug.) 1942.

523. Child, C. G.: Noninfective Gangrene Following Fractures of Lower Leg, Ann. Surg. **116**:721-728 (Nov.) 1942.

such cases have been reported since 1850. The anatomy of the leg is discussed in detail, particularly in regard to the arterial blood supply. The suggestion is made that the bifurcation of the popliteal artery into the anterior and posterior tibial arteries is a particularly vulnerable location, owing to the fixation of the artery to the soft tissue at this point and the proximity of the anterior tibial artery to the upper portion of fibula. He notes that the development of gangrene is gradual, over a period of several days, and that when it once occurs amputation of the extremity apparently is the only remedy. The cases reported present no significant etiologic factor, in age or degree or location of injury. In many of them gangrene developed in the absence of any possible constriction. The patients were treated without plaster support. Child suggests that the cause is probably thrombosis of the anterior or posterior tibial artery or both, due to damage to the intima of the vessel, which causes the development of the gradually enlarging thrombus. He thinks this more probable than an actual occlusion of the vessel at the time of injury. Treatment should be promptly instituted. He suggests heparinization of the patient and relief of any internal pressure by evacuation of the hematoma and other appropriate measures. Repair of the vessel should be done if possible, and some form of sympathetic block must be instituted. [ED. NOTE.—The suggestion that gangrene is due to intimal damage of the vessel seems hardly likely, since intimal damage must occur in a multitude of cases and not go on to thrombosis or to gangrene. His suggestion that this condition be looked for is well made, since if any treatment is to be successful it must be instituted early. It is noted that in the cases reported all but 2 patients had amputations and only 1 obtained a useful extremity.]

Burns and Young [524] analyzed records of 27 patients with simple fractures treated from 1927 to 1930 at St. George's Hospital. Back and side splints were applied for four weeks, during which time massage was given and the joints were gently moved. Then a plaster cast was applied, and the patient was allowed to get about on crutches without weight bearing until union was firm enough for the plaster to be taken off. The average time of union was eleven and one-half weeks. For 95 patients with simple fractures treated in 1941 and 1942 at Botley's Park Orthopaedic Center plaster was applied at the beginning over a thin layer of wool, and the average time of union was fifteen and one-half weeks. A third group of patients, treated by internal plating and insertion of a cross screw at right angles to the other screws without external fixation, had full movement from the start, and there seemed to be firm union by bone in twelve weeks. The authors conclude from their studies that early weight bearing favors union and that traction or use of two transfixation pins for more than a short time hinders union. They suggest that a certain amount of movement in the early stage may be a stimulus to formation of callus and that the much greater immobilization that plaster gives may eliminate this stimulus in the long bones at any rate. They conclude that until a better method is found of obtaining early union without the danger of sacrificing anatomic reduction, the best treatment is plating with a cross screw at right angles to the other screws. [ED. NOTE.—They base their opinion on the cases of 12 patients so treated.]

Dislocations of the Ankle.—del Sel [525] describes a pure tibiotarsal dislocation without fracture in a woman of 31. He discusses the rarity of this injury and points out that the prognosis is somewhat influenced by the common presence of lesions of tendons. He states that the mechanics of the production of these dislocations is difficult to explain and discusses various theories as to the muscular action that brings about the dislocation. [ED. NOTE.—One of the editors (H. E. C.) has treated and reported on 2 patients with complete dislocations of the ankle without a fracture. Both patients had excellent functional results. One

524. Burns, B. H., and Young, R. H.: Time of Union in Fractured Tibia, Lancet **2**:299-301 (Sept. 12) 1942.

525. del Sel, J. M.: Pure Tibiotarsal Luxation, Rev. ortop. y traumatol. **12**:27-32 (July) 1942.

patient had a complete posterior dislocation of the ankle. The second [525a] had a complete internal lateral dislocation.]

Fractures of the Astragalus.—Boyd and Knight [526] have studied 58 cases of fracture of the astragalus, and their report is based on this experience. The astragalus possesses an inadequate blood supply, and it is practically covered with articular cartilage. Because of the various articulations about the bone, accurate reduction of its fractures is important. Open reduction with fixation of fragments is often necessary. If the proximal fragment is dislocated, subastragalar fusion should be done to prevent later deformity of the foot. For extremely comminuted fractures, astragalectomy is the operation of choice. [ED. NOTE.—The authors present an excellent classification of these fractures.]

As a result of study of a series of 30 cases of fracture and fracture-dislocation of the astragalus, Schrock, Johnson and Waters [527] recommend the following procedure in case astragalectomy seems essential: an immediate calcaneotibial arthrodesis, in which, if available, a portion of the astragalus is used as a surface adaptor or wedge to decrease the amount of shortening in the extremity. The tibia is placed with its anterior margin in the vertical plane of the calcaneocuboid joint, and the foot is placed in the optimum position for the individual patient. In males, a minor degree of equinus (5 degrees) may be desirable; in females, the degree of equinus rarely is in excess of 15 degrees. The blood supply to the astragalus is relatively poor, and transcervical fractures interrupt this blood supply. Revascularization is slow, and hence there is a high incidence of aseptic necrosis. There is the necessity of early anatomic reduction by manipulation or by open reduction, with or without internal fixation, as indicated by the stability of the fragments. The articular dome of the body must be smooth and the calcaneo-astragaloid surfaces accurately apposed.

In the cases in which subastragalar contact is faulty, immediate subastragalar arthrodesis is indicated, to obtain earlier function and to prevent pain in the foot on weight bearing. Tibioastragalar arthrodesis is indicated when there has been demonstrable damage to these cartilage surfaces. For compound dislocations with minor fractures, careful cleansing and detailed débridement, coupled with local and general administration of sulfonamide derivatives, give a greater chance for successful conservative surgical treatment. For compound, severely comminuted fractures, the same technic gives a reasonable chance for immediate reconstruction. With certain markedly comminuted simple or compound fractures of the astragalus, reduction and retention of the multiple fragments are impossible. Astragalectomy or calcaneotibial arthrodesis seems a necessity. Calcaneotibial arthrodesis would appear to offer a more satisfactory result than astragalectomy.

Fractures of the Calcaneus.—Gray [528] states that the modern method of treating crush fractures of the os calcis consists in reduction by traction and compression, followed by long immobilization in plaster. The articular facets for the astragalus cannot be completely and accurately restored by this or any other method. In addition, this method promotes stiffness of the foot, incurs the risk of sepsis and encourages compensation neurosis. Conservative treatment leaves a comfortable and mobile foot and avoids the danger of sepsis. Lateral spread if considerable is reduced with a hand clamp; otherwise no attempt at reduction is made. The patient is confined to bed, weight bearing being forbidden but early function encouraged, until the disappearance of deep tenderness shows that adequate consolidation has taken place. This takes two to three months. Alternatively the foot is immobilized for the same period in a plaster cast. These methods were successful in 20 of 23 cases. [ED. NOTE (L. D. B.).—The author's end results are rather unusual for this fracture.]

525a. Conwell, H. E.: Complete Compound Dislocation of Ankle Joint Without Fracture, J. A. M. A. **108**:2035 (June 12) 1937.

526. Boyd, H. B., and Knight, R. A.: Fractures of Astragalus, South. M. J. **35**:160-167 (Feb.) 1942.

527. Schrock, R. D.; Johnson, H. F., and Waters, C. H.: Fractures and Fracture-Dislocations of Astragalus (Talus), J. Bone & Joint Surg. **24**:560-573 (July) 1942.

528. Gray, C. H.: Crush Fractures of Os Calcis, Lancet **1**:106-108 (Jan. 24) 1942.

Dieterle [529] describes a method for treatment of fractures of the calcaneus. In his discussion of compression fractures with alteration in contour, he emphasizes the importance of the salient angle, namely, the angle of intersection of two lines projected on the upper edges of the superior processes. He recommends postponement of reduction until after swelling is reduced, ten days or so, and then the use of skeletal traction. He emphasizes the importance of accurate reduction and the necessity for arthrodesis of the subastragaloid joint in the case of painful weight bearing. In discussing skeletal fixation he states that a window should be cut in the cast for inspection of the pin. [ED. NOTE.—One editor (H. E. C.) finds considerable disagreement with Dieterle's view that reduction should be postponed for a week or ten days while one is waiting for reduction of swelling. His idea of cutting a window for inspection of the pin is certainly open to argument.]

Miller [530] gives a brief but adequate discussion of fractures of the os calcis. He mentions the eight types suggested by Bohler, emphasizing that for practical purposes the fractures can be divided into two groups—those which involve the joints and those which do not. He indicates that a good pair of hands and good surgical judgment are of more importance than many of the commercial machines on the market. He emphasizes the necessity of traction in several directions while the reduction is being carried out and application of a carefully molded plaster cast. He makes a plea for careful and accurate reduction in order to minimize postoperative pain. He suggests that in many cases arthrodesis will become necessary to reduce pain. [ED. NOTE (L. D. B.).—These conservative views from one who has such a thorough knowledge of the foot are worthy of note.]

Gamm [531] reports the only case yet recorded of an arteriovenous fistula in the anterior tibial artery which resulted from the use of a Steinmann pin. A seaman treated for a fracture of the calcaneus had had a pin inserted through the lower third of the tibia. Four months later a pulsating mass developed over the anterior aspect of the tibia, which was found to be due to a communication between the anterior tibial artery and vein. [ED. NOTE.—It is queer that this complication should not occur more often, in view of the wide use of Steinmann pins in fractures of the leg.]

Bankhart [532] states: "The results of the treatment of crush fractures of the os calcis are rotten. They bear no relation to the accuracy with which the fractures are reduced." He expresses the belief that the best result is to be obtained after a fracture of the os calcis involving the subastragalar joint is a completely stiff but painless foot of good shape, and he recommends a complete triple arthrodesis as a primary measure. A slight modification in the operative procedure is offered, in that a short longitudinal incision is first made on the inner side of the foot over the scaphoid for excision of the scaphoid and removal of the cartilage from the head of the astragalus and the base of the cuneiform bone. The usual incision is then made on the outer side of the foot for the calcaneocuboid joint and the subastragalar joint.

Fractures of the Spine.—Snyder [533] reviews the literature on "shoveler's fracture" and notes that few cases have been reported in the American literature, which, in view of the frequent reports in the foreign literature, indicates that physicians in the United States are overlooking this injury to the spinous processes. He makes a plea for roentgen examinations at several angles and careful study of the films, since the injury when overlooked seems to result in continued disability. He describes the mechanism of the fracture of the spinous processes and states that the injury may be preceded by degeneration of the bone. [ED. NOTE.—

529. Dieterle, J. O.: Fractures of the Os Calcis, Wisconsin M. J. **41**:662-666 (Aug.) 1942.
530. Miller, O. L.: Fracture of the Os Calcis, Tr. A. Surgeons South. Railw. Syst. (1941) **1**:7-11, 1942.
531. Gamm, K. E.: Arteriovenous Fistula, J. A. M. A. **119**:134-135 (May 9) 1942.
532. Bankhart, A. S. B.: Fractures of the Os Calcis, Lancet **2**:175 (Aug. 15) 1942.
533. Snyder, C. H.: Shoveler's Fracture ("Schipperkrankheit"), J. Michigan M. Soc. **41**: 847-849 (Oct.) 1942.

Early diagnosis of this injury prevents disabilities. The treatment is simple, consisting of strapping and limitation of function.]

Rogers [534] reviews the recent advances in the treatment of cervical fractures and states that open reduction and internal fixation should be added as modern improvements. He reviews the advantages of skeletal traction and describes in detail a method of reducing dislocations by means of a hook passed through the spinous processes. He describes also an operative fusion in which he uses wire and small osteoperiosteal grafts. Of a group of 11 patients, 10 achieved solid fusion in normal alinement. Owing to a technical error in the operation, 1 patient showed evidence of a recurrence of the displacement. Nine of the patients were able to return to work. [ED. NOTE.—Though laminectomy in the cervical region is a tedious, sanguinary procedure, these results and the accompanying roentgenograms are convincing proof that Rogers' operation is worth while. A great argument in favor of it is the prevention of the troublesome late recurrences of the dislocation.]

Darley, Gordon and Matchett [535] report 9 cases of spontaneous vertebral compression fractures in patients with senile osteoporosis. They state that the factors governing osteoblastic activity are inadequately understood but that atrophy of disuse in the sedentary and aged, endocrine imbalance and dietary inadequacies (in calcium, vitamin C or D or protein) are undoubtedly causatively related. Endocrine imbalance centers about estrogen, the decrease of which, as seen in the postmenopausal syndrome, is associated with increased excretion of calcium and phosphorus. Eighty to 90 per cent of osteoporosis occurs in women between the ages of 45 and 70. Low calcium intake is a common contributing cause, but there is no evidence to indicate that extra amounts stimulate osteoblastic activity. Lack of vitamin D impairs absorption of calcium from the intestinal tract. Bone matrix is protein in nature, and long-standing inadequate intake of protein may have an adverse effect. Adequate intake of vitamin C is also essential to the formation of normal bone matrix.

The prophylactic treatment recommended consists of (1) admonition against lifting and straining (however, a sedentary existence should be avoided at all costs, if possible); (2) correction of dietary abnormalities; (3) reduction of weight, and (4) support for the back and abdomen as needed.

Easton and Sommers [536] studied roentgenograms taken in anteroposterior and lateral views before and after convulsive therapy of the entire spines of 200 patients treated with metrazol (pentamethylenetetrazol). There was evidence of fracture in 23 per cent. In persons over the age of 55 the incidence was 57 per cent (4 out of 7 patients), and in persons under 21 it was 40 per cent (4 out of 10 patients). The higher incidence in the older group is explained by relatively poor bone density, and the lower incidence in the younger, by the fact that the vertebral column in youth has not attained its full adult strength. All fractures occurred in the dorsal portion of the spine, from the fourth to the eighth vertebra, the fourth, fifth and sixth being the most commonly involved. Multiple fractures occurred more frequently in males than in females, owing to the greater muscular development of the former and the more powerful convulsions produced. The clinical symptoms were much milder than would be expected from the roentgenographic evidences of injured spines.

The authors draw the following conclusions: 1. Routine roentgenograms should always be obtained both before and after convulsive therapy. 2. Kyphosis, scoliosis, arthritis, nuclear change and old fractures are no contraindication to metrazol therapy. 3. Osteoporosis is a contraindication. Prophylactic measures recommended consisted of: (1) more careful selection of patients, with avoidance of those under 21 or over 55 and those with osteoporosis; (2) mechanical support

534. Rogers, W. A.: Treatment of Fracture-Dislocation of Cervical Spine, J. Bone & Joint Surg. **24**:245-258 (April) 1942.

535. Darley, W.: Gordon, R. W., and Matchett, F.: Spontaneous Vertebral Compression Fractures Due to Senile Osteoporosis, Rocky Mountain M. J. **39**:193-196 (March) 1942.

536. Easton, N. L., and Sommers, J.: The Significance of Vertebral Fractures as a Complication of Metrazol Therapy, Am. J. Psychiat. **98**:538-543 (Jan.) 1942.

of the spine during convulsions by a firm mattress and bed boards, and (3) extension of the spine over a sand bag and holding the shoulders down during convulsions. Spinal anesthesia is not recommended. Curare may be of value and is being tried. When a fracture has occurred, the treatment is a matter of judgment. Usually no treatment at all or about two weeks of rest will suffice. When compression to one half or less of the original height of the vertebral body occurs, the treatment by cast or by Bradford frame is indicated. Many of the patients have been discharged from the hospital and have been gainfully employed for one to two years without any complaints referable to the spine. [ED. NOTE (L. D. B).—Many orthopedic surgeons will not agree with the author's recommendations as to treatment of the fractures.]

Worthing and Kalinowsky [537] report that 40 per cent of patients treated with metrazol acquire compression fractures of the vertebral bodies between the fourth and the eighth dorsal level. This localization differs from that of the purely traumatic fractures, which usually occur between the twelfth dorsal and the second lumbar vertebra. In order to determine whether secondary changes develop in the metrazol-treated group, 8 patients who had multiple fractures were followed for two years. Complete healing occurred, with no progressive pathologic changes, no evidence of Kümmell's disease, no limitation of spinal motion, no pain and no radiculitis. Of 42 epileptic patients studied for comparison, none had middorsal fractures, 1 had a definite compression fracture of the body of the first lumbar vertebra and 1 had evidence of an old fracture of the spinous process of the sixth cervical vertebra. This difference between the metrazol-treated group and the epileptic group indicated a fundamental difference between artificially and naturally produced convulsive seizures. In persons with tetanus compression fractures identical with those seen in the metrazol-treated group have been reported. The authors offer the explanation that a fully developed generalized seizure always has essentially the same features, the tonic and the subsequent clonic phase. The only difference between artificially produced seizures and spontaneous convulsions is the onset. In metrazol convulsions there is an abrupt onset, with a "first clonic phase," which does not occur in epileptic convulsions. The convulsions of tetanus likewise have an abrupt onset. With electric shock therapy compression fractures are much less frequent than with metrazol therapy. The reason is that there is a latent period without an abrupt onset before the generalization of the seizure. (However, if a high voltage is used an abrupt onset will occur without the latent period and fractures similar to those produced by the metrazol convulsions will develop.) Electric shock therapy is therefore superior to administration of metrazol. By using an improved technic, with extreme hyperextension of the spine in addition to electric shock therapy, the authors were able to treat 60 patients without any fractures developing. The authors conclude that there is no contraindication to shock therapy because of the occurrence of fractures, since they can be successfully avoided and if they do occur have no clinical significance. [ED. NOTE.—One of the editors (L. D. B.) does not agree with the authors' statement that if the fractures do occur they have no clinical significance. In many cases, owing to the patient's age or to other factors, treatment is contraindicated and the results are poor.]

Fractures of the Jaw.—Waldron [538] gives a comprehensive discussion of the treatment of the various types of fractures of the mandible. He emphasizes the frequency of multiple fractures about the face and jaws and the necessity for detailed study. He states that in the majority of instances manual reduction can be carried out successfully and can be followed by fixation by interdental wiring, which gives tight apposition at the site of fracture. While he states that many fractures will require some special type of apparatus for fixation, it is his opinion

537. Worthing, H. J., and Kalinowsky, L. B.: Question of Vertebral Fractures in Convulsive Therapy and in Epilepsy, Am. J. Psychiat. **98**:533-537 (Jan.) 1942.

538. Waldron, C. W.: Fractures of the Mandible with Special Reference to the Reduction of Complicated Displacements and Subsequent Immobilization, Journal-Lancet **62**:228-240 (June) 1942.

that 90 per cent of fractures of the mandible or maxilla can be efficiently treated by one or another of the standardized methods of wiring. He discusses the various types of fractures of the mandible, with a detailed description of the simplest type of fixation for each type. He details many methods by which posterior fragments can be secured by traction from the angle of the jaw, such as extraoral fixation with screws and pins, intraoral application of splints and various surgical procedures. The multiplicity of the methods indicates that none of them is entirely successful, and he mentions the many complications resulting from the various types. The problem of partially edentulous mandible bone is discussed in some detail. He emphasizes that if direct surgical fixation is secured it must be in addition to fixation of the upper and lower jaws. He suggests that probably it is not necessary to remove a dislocated head of a fracture condyle, since the result seems to be essentially the same whether the fragment is or is not removed. If both condyles are broken, there is a tendency for the jaw to fall backward, and it is important to pull the jaw forward in order to secure proper alinement of the upper and lower jaws.

Waldron,[539] in collaboration with Kazanjian and Parker, presents a review of the various methods of external skeletal fixation for fractures of the jaw, including various modifications of the Roger-Anderson method, using two pins in each fragment, attached to a fixation bar, by universal joints. Many modifications of this method are described in some detail with comments by the authors. The second method of fixation, by skeletal wires transfixing the fracture line passed along the long axis of the mandible, is presented and discussed. Since this article is essentially a review of the literature, it is impossible to review this article in any detail. The authors' summary and conclusions are as follows:

> The present methods of skeletal fixation as used by a number of men are the logical refinements of what preceded, and they will undoubtedly go through a further developmental stage until they assume a definite and permanent place in the treament of fractures of the mandible. There are many possibilities for its employment when used intelligently, but we all fear its misuse in the hands of the overenthusiastic. The illustrations and roentgenograms of many published reports show its use in cases wherein the standard and simpler procedures could have been employed with a greater assurance of a more nearly perfect restoration of the occlusion of the teeth. They state: "let us welcome any new method of fixation offered for the treatment of fractures, but we should be discriminating and critical at first, and use it intelligently. Otherwise, failures may not only do harm to the patient, but may also bring disrepute to the method which it does not deserve.

Spanier [540] describes a modification of a simple splint for fixation of severe fractures of the mandible or maxilla before emergency transportation of the patients to the hospital, where treatment can be carried out. Briefly, the splint consists of a well fitted cap of any sort, which must fit snugly to the head. Wooden tongue blades are fastened together to make a strip about 12 inches (30 cm.) long, considerably reenforced. A crossbar of a single tongue blade is made halfway down the strip. The whole is then fastened vertically from the forehead, paralleling the nose and bisecting the face. A pad of cotton is placed under the strip over the forehead. For mandibular fractures the mandible can be pulled forward to the end of this wooden strip either with a wire or with suture material around the teeth, or if necessary through the soft tissue of the chin to hold the chin up and forward. In fractures of the maxilla similar fixation can be obtained by wiring around the teeth and up to the crossbar of the splint. [ED. NOTE.—This is an ingenious splint and certainly should provide more comfortable and safe transportation than the ordinary method of fixation.]

Kazanjian [541] comments in general on the difference between civilian injuries to the jaw and war injuries, noting that the war injuries often involve extensive loss of substance, not only of soft tissue but of bone. Their treatment is much more complicated. He emphasizes the importance of early treatment, before scar

539. Waldron, C. W.: Skeletal Fixation in the Treatment of Fractures of the Mandible, J. Oral Surg. **1**:59-83 (Jan.) 1943.

540. Spanier, F.: First Aid Splinting of Broken Jaws, M. Rec. **155**:377 (July) 1942.

541. Kazanjian, V. H.: Immobilization of Wartime, Compound, Comminuted Fractures of the Mandible, Am. J. Orthodontics (Oral Surg. Sect.) **28**:551-560 (Oct.) 1942.

formation occurs in the soft tissues, as the best means of securing adequate cosmetic and functional results. The three types of fractures discussed specifically are: (1) fractures of the anterior part of the mandible with teeth in the posterior segment; (2) fractures of the lateral part of the mandible with teeth remaining posterior to the injury on one side only, and (3) fractures with a distinct loss of bone. He describes various apparatus for fixation of the fragments and methods for securing small comminuted fragments to the general contour of the mandible. He emphasizes particularly that the methods described were used during the last war and he thinks they are equally applicable in this one. He states that in treating fresh fractures of the jaw, speed, efficiency and simplicity are important, and the fixation apparatus should be applied promptly.

With fractures at the angle of the mandible there is often displacement, and, since the proximal fragment is toothless, there is no secure way of immobilizing the fracture after it is reduced. Converse and Waknitz [542] have developed an external fixation bar which is attached to pins in each fragment. The entire apparatus can be locked together after reduction, if obtained. In this way, the patient has a movable painless jaw while healing is taking place. With proper precautions the danger of infections about the pins is minimal.

For treatment of fractures of the jaw seen some time after the accident, compound fractures, fractures in edentulous jaws, comminuted fractures near the symphysis, and fractures at the angle of the jaw in which the posterior fragment is displaced into the upper buccal fornix, Brown and McDowell [543] have devised a simple, ingenious and effective method of fixation. A Kirschner wire is drilled transversely across the line of fracture, and if necessary an interdental wire is also used to supplement the fixation. This gives immediate comfort; no external bandages or splints are needed, and the results so far have been excellent. The wires are easily removed after four or five weeks, so that there is no persistent disfiguration or danger of late complications. [ED. NOTE.—These methods are not panacea, neither should a novice use such technic. Serious complications can and do and have occurred in the hands of those who are not experienced with the use of appliances for external fixation.]

Fractures of the Malar Bone.—Balkin [544] gives a description of the anatomy of the malar bone, emphasizing that the so-called fracture of the malar bone is ordinarily displacement, since this bone gives away from its attachments to the surrounding structures. He emphasizes the importance of the fact that the malar bone makes up a considerable portion of the orbit and points out that accurate reposition is necessary. He describes a test of ocular balance to determine vertical displacement and states that any great degree of vertical displacement of the eyeball is indication for replacement, since this muscular imbalance of the eye is apt to be permanent if displacement is extensive. He deplores too much dependence on roentgen examination, stating that in many cases the x-rays do not actually visualize the deformity and that clinical examination is more important. Several methods of elevation of the bone are described; he prefers reduction by use of a tenaculum and direct traction.

Injuries of the Nose.—Waldron [545] in a comprehensive article describes the various types of fractures of the nose. He emphasizes the importance of careful suturing of lacerations and careful lavage of the wound if one is to obtain good cosmetic results. He gives a classification of the types of fractures of the nasal bone, with a treatment for each. He emphasizes the importance of clinical diagnosis. A description of the anatomy of the nose is given as a preliminary to

542. Converse, J. M., and Waknitz, F. W.: External Skeletal Fixation in Fractures of Mandibular Angle, J. Bone & Joint Surg. **24**:154-160 (Jan.) 1942.

543. (*a*) Brown, J. B., and McDowell, F.: Internal Wire Fixation for Fractures of Jaw: Preliminary Report, Surg., Gynec. & Obst. **74**:227-230 (Feb.) 1942. (*b*) Brown, J. B., and McDowell, F.: Internal Wire Fixation of Jaw Fractures: Second Report, with Note on External Bar Fixation, Surg., Gynec. & Obst. **75**:361-368 (Sept.) 1942.

544. Waldron, C. W.; Balkin, G. G., and Peterson, R.: Fractures of Facial Bones in Children, J. Oral Surg. **1**:215-234 (July) 1943.

545. Waldron, C. W.: Injuries of the Nose, Minnesota Med. **25**:258-267 (April) 1942.

treatment. He discusses fractures of the nasal septum and comments that many fracture-dislocations of the septum can be reduced promptly and will hold a certain portion of the reduction. The majority of them, however, if there is serious displacement, will require a plastic operation, which is better postponed until healing occurs. [ED. NOTE.—This is an excellent and comprehensive article.]

Compound Fractures.—Macpherson [546] concludes that the best method of handling war wounds is (1) soap and water cleansing of the skin, (2) débridement, with removal only of devitalized tissue and elimination of pockets and (3) generous application of sulfanilamide followed by a nonocclusive type of dressing. Physiologic rest of the part is best gained by the use of a plaster cast, whether the lesion be a fracture or lacerated wound. Dressings should be performed as infrequently as possible. In times of stress traumatic wounds may be safely treated by the use of sulfanilamide and a sterile dressing with débridement postponed and primary suture postponed for as long as seventy-two hours or perhaps even longer. Sulfanilamide in crystalline form which does not have to be sterilized and can be contained in an ordinary salt shaker is the drug of choice, since it is readily absorbed and does not cake in wounds. [ED. NOTE.—One of the editors (L. D. B.) believes that sulfathiazole in small amounts has a higher bacteriostatic effect on staphylococci, remains longer in the wound and is a more efficient drug than sulfanilamide.]

Ponseti and Guri [547] give a comprehensive and instructive discussion of treatment of injuries, particularly compound fractures, during the Spanish civil war. They divide the discussion into three divisions: (1) treatment on the battle field; (2) treatment in the surgical station, and (3) treatment in the base hospital. With regard to treatment on the battle field, it is emphasized that the essential treatment is to provide immobilization and to control bleeding. Only superficial cleansing was done; no treatment was attempted for the fracture. They note that, although tetanus antitoxin was very useful, anti-gas-gangrene serum appeared to be useless and was seldom used after the first year of the war. Prompt evacuation to a hospital train, to a hospital trailer or to a field hospital was recommended. A comprehensive discussion of treatment in the surgical station is given, including the general organization of the station. Wounds of the extremities are discussed in great detail, particularly their treatment by the closed, or Orr, method versus the open air method. It is emphasized that in each method an adequate surgical procedure is the most important factor, and considerable discussion is given as to technic, emphasizing that all traumatized tissue should be removed and that none of these wounds should be closed. A general order was issued that no wound requiring débridement should be closed. Drainage was instituted with petrolatum gauze or otherwise, and the extremity was immobilized in a plaster cast. The difference between the Orr method and the open air treatment (the latter entailing a window in the cast for observation of the wound) is presumed to be understood. The authors emphasize particularly the importance of not removing a great deal of bone substance and of not disturbing the area of the fracture any more than necessary. They state that it is much more important to do a careful débridement on the soft tissue than it is to meddle with the bone. They emphasize again that application of chemicals for disinfecting the wound is useless. The third subject of discussion is treatment in the base hospital. A rather limited sketch is given as to the various types of after-care. Two complications seemed most common: development of an abscess in the wound, which required opening for adequate drainage and secondary débridement, and development of secondary hemorrhage, which was a much more serious complication and often required ligation of the main vessel to the extremity and subsequent amputation. The authors mention the definite contraindications for the Orr method as being, first, necessity for prompt evacuation of the patient, which would entail his removal from observation for a period of several hours or several days, and, second, the patient's

546. Macpherson, J. D.: War Wounds of Extremities Involving Bone, Hawaii M. J. **1**:261-262 (March) 1942.

547. Ponseti, I., and Guri, J. P.: General Principles in the Treatment of Wounds and Fractures in the Spanish War, Mil. Surgeon **91**:39-48 (July) 1942.

being received from the battle field late, after infection has actually developed. The authors state that they believe that the Orr method properly carried out, and with regard to its contraindications, is the ideal treatment for persons wounded on the battle field. [ED. NOTE.—This report is a comprehensive and thoughtful article presenting interesting phases developed from actual experience in the treatment of war injuries. It merits careful study.]

Baker [548] collected a series of cases from personal communications in which one or more sulfonamide compounds were used in treatment of three groups of conditions: (1) fresh compound fractures, (2) old infected compound fractures and (3) chronic osteomyelitis. In a series of 270 cases of fresh compound fractures, sulfanilamide or sulfathiazole, or a combination of the two, with or without oral administration of one or the other drug, were used. The general impression from this series was that there had been some improvement in the infection rate, but whether this was due to more meticulous surgical technic or to the drug the author is unable to state. The final incidence of severe infections in the 270 fractures was about 10 per cent. The incidence of all infections, either severe or mild, was about 20 per cent. He emphasizes the importance of careful surgical technic and the danger of depending on the sulfonamide drugs rather than on proper surgical intervention. Of old compound fractures with infection, 47 cases were reported, with results that were encouraging but inconclusive because of the small series. Seventy-four cases of chronic osteomyelitis were reported, with good results, only 16 per cent of the patients having final residual infection. The impression was that there was improvement as a result of use of the drug and of the closed method as described by Dickson and Diveley.

Swett [549] urges caution in the use of sulfonamide compounds in the treatment of war wounds and compound fractures, deploring its use in substitution for careful and adequate treatment. He emphasizes again the danger of relying on chemotherapy and neglecting proper surgical care. He reviews the proper treatment of wounds by débridement and suggests that, while in many cases the wounds may be closed tightly, if there is danger of local accumulation of tissue fluid, drainage should be instituted. In cases of massive destruction of tissue he recommends the use of the Orr technic. He urges the use of plaster rather than splints in order to prevent edema of the tissues and to get adequate fixation to soft parts as well as to bone. [ED. NOTE (L. D. B.).—The author's recommendation of the use of plaster fixation is most timely in view of the present enthusiasm for pins and external fixation.]

Orr [550] states that the principles of modern treatment of a compound fracture must be not a technic, a method or a chemical cure, but a program. If a complete regimen can be applied to every compound fracture situation, which includes immediate reduction of fractured bones and neighboring soft parts, provision of adequate drainage, immobilization in correct position during healing and recovery with the limb in the best length and position for ultimate function, then the wound will take care of itself. He outlines the following procedure: For open infected fractures or fractures requiring surgical operations, immobilize the patient at once in traction and in the best position on the operating table. Do a thorough débridement or drainage operation if necessary. Pack the entire wound open with sterile petrolatum gauze, using no sutures, drainage tubes or antiseptic dressings. Apply an extensive, well fitting plaster of paris cast. Do not change dressings or disturb the cast, the wound, the dressings or the injured part except when there are definite local complications.

The greatest service a surgeon can render to a patient with a compound fracture is to (1) protect him against further injury, (2) restore all the injured parts to correct anatomic relationship at the earliest possible moment, (3) provide

548. Baker, L. D.: Sulfonamides in Traumatic and Infected Wounds, J. Bone & Joint Surg. **24**:641-646 (July) 1942.

549. Swett, P. P.: Chemotherapy in War Wounds and Compound Fractures, Connecticut M. J. **6**:713-715 (Sept.) 1942.

550. Orr, H. W.: The Treatment of the Infected Wound in Compound Fractures, S. Clin. North America **22**:1135-1152 (Aug.) 1942.

adequate drainage for all areas of infected or contaminated tissue, including bone, (4) maintain correct length and position, absolutely, and (5) protect the patient against trauma and infection and even against himself until he has obtained as good a result as his injured parts will permit.

The long series of articles by Orr is well combined in the article from the *Surgical Clinics of North America*. He reviews again the history of treatment of wounds and compound fractures. He elucidates the principles on which modern treatment, which is in effect the Orr treatment, is based. He gives in great detail the Orr method of treatment and concludes:

> My conclusions from twenty years of observation at home and abroad seem to me to be unavoidable. 1. The greatest service that a surgeon can render to the compound fracture patient is to (*a*) protect him against further injury, (*b*) restore all the injured parts to correct anatomic relationship at the earliest possible moment, (*c*) provide adequate drainage for all contaminated or infected tissue areas—including the bone, (*d*) maintain correct length and position—not relatively, but absolutely—for physiologic function during healing and for use of the injured part upon recovery, and (*e*) protect the patient against trauma, against infections, and even against himself until he has obtained as good a result as his injured parts will permit. 2. That surgeons now are easily misled by mercurochrome, by maggots, and the sulfa drugs as Lister and his associates were by the mercurial antiseptics, boracic acid, and other chemicals useful as germicides but not cures for wound infection. Chemical irrigation or the antiseptic wet dressing as a cure for infected wounds is as much a fallacy as the carbolic sterilization of the atmosphere. 3. And, that, finally, compound fractures call not for a cure but a program—which I have here ventured to propose.

[ED. NOTE.—There is no question that the Orr method for treatment has tremendous advantages over older methods, and it is particularly applicable for treatment of war casualties, but it should have combined with it any benefits that are to be derived from the use of the sulfonamide drugs.]

Weil, Whitaker and Rusbridge [551] present a review of their records on the local use of sulfathiazole in the treatment of compound fractures and traumatic wounds. "The greatest value of sulfathiazole is the inhibitor-reducing properties of the drug when applied locally in sufficient amounts at the earliest possible period following the injury to tissues."

Many investigators have found that sulfonamide compounds have little or no detrimental effect on the defensive mechanisms of tissue cells. Wounds heal in normal time without excess serum or scar tissue. Microscopic studies of tissues from skin grafts treated with sulfathiazole showed granulation tissue to appear normally, and there was adequate production of collagen and capillaries. Traumatic wounds should be treated with sulfonamide compounds during the period of contamination, which is agreed to be the first four to six hours. Sulfathiazole is recommended by the authors for use after preliminary culture, immediate débridement and irrigation and complete hemostasis. The wound should be closed without drainage and the part placed at rest by splinting. Patients with osteomyelitis have responded favorably to treatment by placing healthy bone chips in the thoroughly curetted cavity, filling it with sulfathiazole and closing the wound. Immobilization is essential. Few organisms were found in routine bacteriologic studies in cultures of wounds in the first six hours. Positive cultures were obtained from 50.5 per cent of compound fracture wounds and from 39.9 per cent of wounds in the soft tissues. The antibacterial effects of sulfathiazole used locally offset any local irritation or delayed healing which may result. Local application does not present the hazards of oral administration as the rate of absorption is low. In 185 reported cases of compound fractures, traumatic wounds and simple fractures requiring open reduction, 8 deaths resulted, to 1 of which sulfathiazole was felt to be a contributing factor. During the administration of sulfathiazole, renal function should be well balanced and maintained to prevent gross damage to the kidneys. No clinical or electrocardiographic evidences of cardiac change have been noted after administration of sulfathiazole. One patient with subacute bacterial endocarditis received 5,000 grains (300 Gm.) of sulfathiazole without any evidence of cardiac

551. Weil, G. C.; Whitaker, D. W., and Rusbridge, H. W.: The Local Therapeutic Effect of Sulfathiazole, Am. J. Surg. **55**:374-385 (Feb.) 1942.

involvement. Observations on the combined use of zinc peroxide and iodine and sulfathiazole have so far been favorable.

Frankel and Funsten [552] report 20 from a series of 28 cases of compound fractures of long bones in which sulfonamide drugs were used locally. All the patients were seen within eight hours except 1, who was not admitted to the hospital until twenty-four hours after the injury. Routine treatment for compound fractures was used in all the cases. This includes: (1) immediate splinting; (2) sprinkling the wound with sulfanilamide or sulfathiazole or both; (3) shock therapy; (4) in the operating room, thorough débridement and irrigation; (5) closure of the wound if seen during the eight hour safe period and if no tension is present; (6) sprinkling the wound with a sulfonamide compound before closure; (7) after reduction, application of a snug plaster. No infections developed in the 28 cases. Nonunion occurred in 1 case of fracture of the humerus in which there was much loss of bone and soft tissue. Amputation was advised, but the patient refused. The time required for union varied from sixteen to forty weeks with the fractures of the tibia. Frankel and Funsten feel that the use of sulfanilamide or sulfathiazole in the wound at the scene of the accident or on the patient's admission to the hospital is of value in preventing infection.

Jensen and Nelson [553] give a summary of experimental investigations of the effects of sulfanilamide on compound fractures of the ribs in guinea pigs with the wounds contaminated by staphylococci, streptococci or Clostridium welchii, or a combination of any two. Sulfanilamide has been found to be more effective when implanted locally than when administered systemically in the prophylaxis of wound infection. Local application of sulfanilamide will not prevent infections in the presence of massive numbers of contaminating organisms, although it does appear to lessen the severity of infection. Devitalized tissue will inhibit the activity of locally implanted sulfanilamide. Foreign particulate matter will protect the contaminating organisms against sulfanilamide. Sulfanilamide locally administered is more effective against Cl. welchii and Clostridium histolyticum infections than the systemically administered drug. It is of little value against Clostridium septicum or Clostridium oedematiens with either route of administration. In wounds carefully excised gas bacillus infections are rare unless invasion and devitalization of the tissue by virulent aerobic organisms occur (e. g. hemolytic streptococci). Locally implanted sulfanilamide will protect against this type of infection and consequently greatly reduce the incidence of anaerobic infection. Sulfathiazole locally implanted is effective against Cl. septicum (Hawking). Polyvalent serum (antitoxin) seems to be the most effective agent against Cl. oedematiens (Hawking). Delay of even one hour in local implantation of the drug in wounds contaminated with gas bacilli materially reduces the effectiveness of sulfonamide compounds (Legroux). The antibacterial action of sulfanilamide is directly proportional to the temperature. It is suggested that means be used to keep the temperature of a wound at 37 C. or above during the first twenty-four to thirty-six hours. A summary of clinical results in 212 consecutive compound fractures and 15 compound fracture-dislocations shows: (1) The incidence of infection was 4.4 per cent (since 2 of the fractures were due to secondary contamination after infection had been eliminated from wounds, the incidence of infection is really 3.3 per cent); (2) débridement and immobilization remain the basic essentials of successful treatment of compound fractures; (3) with careful débridement and local application of sulfanilamide, internal fixation with vitallium can be safely and perhaps advantageously undertaken (20 compound fractures have been internally fixed without a single instance of wound infection); (4) interrupted fine silk suture is used for buried ligatures and sutures as well as cutaneous closure; (5) prophylactic anti-gas-gangrene serum as well as tetanus antitoxin should be routinely

552. Frankel, C. J., and Funsten, R. V.: Compound Fractures: Report of Twenty Cases in which Sulfonamide Drugs Were Used Locally Almost Immediately After Injury, J. A. M. A. **120**:1384 (Dec. 26) 1942.

553. Jensen, N. K., and Nelson, M. C.: Local Sulfanilamide in Compound Fractures: Experimental and Clinical Evaluation, Surg., Gynec. & Obst. **75**:34-48 (July) 1942.

used in cases of traumatic wounds even though adequate débridement is done and sulfanilamide powder is implanted in the wounds.

The use of sulfanilamide in wounds reduced the incidence of infection in compound fractures treated at the Minneapolis General Hospital from 27 per cent to 3.3 per cent. It reduced the average stay of patients in the hospital from ninety-six and three-tenths to thirty days. Two cases of gas gangrene occurred (less than 1 per cent) in 212 consecutive cases of compound fractures treated with local implantation of sulfanilamide, while 7.3 per cent of the control patients treated without sulfanilamide had gas gangrene. [Ed. Note (L. D. B.).—This report comes from the Minneapolis General Hospital, where the first clinical studies of the local use of sulfonamide compounds as a therapeutic measure were made. It is an excellent summary.]

Épluchage (excision of a war wound in its entire extent) is, according to Fruchand,[554] the most important curative factor. All other therapeutic procedures are secondary, and even after an initial delay this treatment can be carried out with success. This term implies a much more extensive operation than débridement or enlargement of a wound. The latter has been in vogue since the wars of the sixteenth century, while épluchage was perfected as a method in 1915-1916.

Fruchand does not use suture in any traumatic wound. "It is not worth the risk, if the result is to effect a cure of ninety per cent in fifteen days, instead of one hundred per cent in two months."

The closed plaster method of treating wounds was described by Ollier in 1870 and was rediscovered in the years from 1914 to 1918. It has been used by the author for twenty years with consistently good results. Immobilization of wounds is complementary to epluchage but does not compensate for inadequate surgical treatment. Immobilization is advocated for large muscular lesions and for wounds of nerves or muscles which may result in malposition. The results of epluchage are better the earlier the procedure is carried out, although many wounds will recover after much delay if the wound is thoroughly opened and any fracture completely immobilized.

The author states: "In the use of sulphonamides . . . we must beware of the exaggerated enthusiasm of certain American writers. . . . This is undoubtedly an excellent auxiliary treatment, but it will never prevent complications without surgical intervention." [Ed. Note (L. D. B.).—A review of the American literature will acquaint the author with the fact that thorough surgical treatment has been recommended by the American surgeons and that a majority of their articles have been written as a warning against any tendency to let the sulfonamide compounds cause them to grow careless.]

Pathologic Fractures.—Sirbu and Palmer[555] report 15 cases of march fracture occurring in the armed forces. It is their opinion that march foot is the result of a definite fracture of the metatarsal occurring in an inherently weak foot. They comment that in all of their cases, and indeed shown in all of the roentgenograms that have appeared in reports of other cases, there has been a short first metatarsal. They conclude that injury occurs from imbalance of the foot that causes undue strain on the second and third metatarsals, which are ill fitted to carry on the unusual stress thrown on them when the person goes into active army training, particularly with addition of a heavy pack. Their fractures were evenly divided between the second and third metatarsals, which again added to their conviction that the condition is due to undue stress on these two metatarsals, caused by faulty distribution of weight bearing, in which the first metatarsal does not carry its share of the weight. The treatment suggested is either immobilization or, as in the majority of their cases, simple strapping of the foot with padding to support the weight away from the involved metatarsal. [Ed. Note.—It has been our experience

554. Fruchand, H.: Treatment of Recent War Wounds: French and Spanish Methods, Lancet **1**:725-727 (June 20) 1942.

555. Sirbu, A. B., and Palmer, A. M.: March Fracture: A Report of Fifteen Cases, California & West. Med. **57**:123-127 (Aug.) 1942.

that almost every patient with march foot required a certain period of rest and fixation in the early convalescent period.]

Peterson [556] states that with the expansion of the Army there has been an increase in march fractures of metatarsals but that spontaneous development of a crack through the lower end of the shaft of the femur has not previously been observed in this country. The findings are typical and resemble those of march fracture in the foot. Treatment is simple, and complete recovery follows adequate immobilization. [ED. NOTE.—It has come to our attention that Lt. Col. P. M. Girard, chief of orthopedic surgery at Brooke General Hospital, Fort Sam Houston, San Antonio, Tex., has observed 3 such cases, which he will report later.]

Epiphysial Separations.—Sloane [557] reports on a patient 12 years of age who received an injury to the wrist with dorsal displacement of the distal radial epiphysis. Reduction was similar to the treatment of Colles fractures, and a normal wrist resulted. [ED. NOTE.—The author quotes Aitkens' [558] work in which it is stated that while perfect reduction of the displacement is desirable good results invariably follow even if reduction is not complete. Subperiosteal new bone repairs any defects so that there is no residual disability. The conclusions of one editor (L. D. B.) are that this is not always the case; neither does it warrant neglect or an indifferent attitude toward a diligent attempt at closed reduction with complete replacement of the displaced epiphysis.]

Kaplan, Sprague and Benjamin [558a] report a case of bilateral traumatic separation of the distal femoral epiphyses without accompanying fracture as a result of extensive injuries to both knees in a child of 11 years. Roentgenograms revealed complete separation of the distal femoral epiphyses with anterior rotation and displacement. With the patient under general anesthesia, traction was applied, and then each leg was forcibly flexed under the thigh while gentle pressure was applied over the epiphysis. Long leg casts were applied with the knees in acute flexion. Roentgenograms revealed perfect reduction. Eight weeks later the casts were discarded and motion begun. Two and a half months later the patient was able to walk without support, and at the end of three and a half months the child had no limitation of motion and walked without a limp. Roentgenograms taken five months after the accident disclosed perfect healing.

External Skeletal Pin Fixation for Fractures.—The results obtained in 40 patients treated by the Stader reduction splint by Shaar and Kreuz [558b] are reported as far more satisfactory than those obtained by any other method previously employed by the authors. The splint is described as being applicable in the treatment of various fractures and in bone grafts, bone lengthening and joint transfixion. The outstanding advantages of this splint, according to the authors, are its structural strength and comparative light weight and its mechanical design, which permits complete control of bone fragments in all planes as well as traction, impaction and fixation. Since the method embodies the basic requirements of accurate reduction, rigid uninterrupted immobilization, immediate active motion and early restoration of function in a single compact unit, it is the most ideal for use aboard ship and in field hospitals and for treatment of a large number of fracture casualties in the shortest period of time. The postoperative care is reduced to a minimum. Joints are free for active motion, and therefore the splint favors earlier union. Insulation of the pins to prevent electrolysis about them is under study. The observations are encouraging, but not yet entirely conclusive. [ED. NOTE (L. D. B.).—Many of the patients who have reported to my associates and me in our clinic

556. Peterson, L. T.: March Fracture of Femur: Report of Case, J. Bone & Joint Surg. **24**:185-188 (Jan.) 1942.

557. Sloane, D.: Traumatic Displacement of Lower Radial Epiphysis, Arch. Pediat. **59**: 594-596 (Sept.) 1942.

558. Aitken, A. P.: The End Results of the Fractured Distal Radial Epiphysis, J. Bone & Joint Surg. **17**:302 (April) 1935.

558a. Kaplan, J. A.; Sprague, S. B., and Benjamin, H. C.: Traumatic Bilateral Separation of the Lower Femoral Epiphyses, J. Bone & Joint Surg. **24**:200-201 (Jan.) 1942.

558b. Shaar, C. M., and Kreuz, F. P., Jr.: Symposium on New Trends in Surgery: Treatment of Fractures and Bone and Joint Surgery with Stader Reduction and Fixation Splint, S. Clin. North America **22**:1537-1583 (Dec.) 1942.

for treatment following the use of the various "pin and external splint" appliances have had draining sinuses about the sites of insertions of pins. The study of the insulation of the pins to prevent electrolysis is of interest.

Lewis, Breidenbach and Stader [558c] present here in detail the construction of and application of the Stader splint, which was first developed for use in dogs. They state that some 1,200 animals have been treated with satisfactory results. The apparatus is one used to connect two half-pins inserted on each fragment of a fracture of a long bone. The principle is similar to that used by Roger-Anderson with his half-pin and external traction splint. The authors present 20 cases, with details on 4. In the 4 cases reported on in detail the results were excellent. They report, however, 3 cases of serious infection about the site of the pins which represents some 15 per cent of the cases in which the method was used. [ED. NOTE.—A 15 per cent incidence of infection seems rather high, considering the many other satisfactory methods which can be used for similar types of fractures. This splint is being given extensive trials at various hospitals, and the final word has not been given as yet. It probably will be found to be highly useful in certain selected cases but hardly applicable for routine treatment for fractures of the long bones. When it is used, it should be by a surgeon who knows how to use it and who knows its limitations.]

Convalescent Care of Patients with Fractures.—Kennedy [558d] makes a timely appeal for proper convalescent care of patients with fractures. He makes many practical suggestions: A patient with a fracture enters the hospital a broken man but not a sick man. It is the doctor's responsibility to keep him from becoming ill. A separate fracture ward is better for morale than placing patients with fractures among those who are ill. It is stimulating to have a set time for daily calisthenics in bed, which keep normal extremities from becoming soft and flabby. A well developed social service department enables the patients to feel that some one really cares how they get along. Occupational work in bed helps overcome the tendency to give up and leave it all to the compensation board. [ED. NOTE.—These high lights give only a rough outline of the intelligent approach made by the author to the problem of preserving patients' morale.]

B. FRACTURES OF THE NECK OF THE FEMUR

Hart [559] in reporting 2 cases of fracture of the femoral neck emphasizes the importance of the difference between the adduction type of fractured neck of the femur, in which there are a separation of the fragments and a shearing force across the line of fracture that tend to keep the fragments apart and prevent union, and the abduction type, in which the fracture is impacted and the head is thrown into valgus position on the neck and fortunately either weight bearing or muscular pull forces the fragments together rather than apart. With the first type of fracture it is important to get adequate fixation, preferably internal fixation, in order to secure union. The second type of fracture is already impacted and in excellent position. This type of fracture always unites without any special form of treatment, the author states. [ED. NOTE.—The author's last statement should be modified as follows: "In most instances an impacted valgus fracture of the femoral neck unites."]

Compere, Wallace and Lee [560] discuss various materials for internal fixation of intracapsular fractures of the neck of the femur. Hips obtained at necropsy

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558c. Lewis, K. M.; Breidenbach, L., and Stader, O.: The Stader Reduction Splint for Treating Fractures of the Shafts of the Long Bones, Ann. Surg. **116**:623-636 (Oct.) 1942.

558d. Kennedy, R. H.: Convalescent Care of Patients with Fractures, Am. J. Surg. **55**: 309-316 (Feb.) 1942.

559. Hart, V. L.: Fractures of the Neck of the Femur, Surgery **12**:763-767 (Nov.) 1942.

560. Compere, E. L.; Wallace, G., and Lee, J.: Materials for Internal Fixation of Intracapsular Fracture of Neck of Femur, Arch. Surg. **44**:327-338 (Feb.) 1942.

were freed of all soft tissue with a minimal amount of trauma to the periosteum, but no dissolving, decalcifying or fixing chemicals were used. Each femur was mounted in a plaster of paris cylinder which extended just above the lesser trochanter. A concave plaster mold was made to fit over the femoral head, so that force could be directed downward on the head over a wide area by means of a hydraulic press. All hips were fractured with a measured force, and most fractures of the neck occurred from the superior edge of the head downward and laterally toward the lesser trochanter. The average force of fracture in a group of 13 hips was 1,655 pounds (745 Kg.); in a group of 5 the force was 1,769 pounds (796 Kg.), and in a group of 4 it was 1,456 pounds (655 Kg.). After almost anatomic reduction, insertion of three highly tempered stainless steel wires, gage 0.080, with fifty-six threads to the inch, the breakdown or refracture force averaged 455 pounds (205 Kg.) for the first group, of 13 hips. In the second group, of 5 hips, three Steinman pins were introduced, and the breakdown force averaged 372 pounds (167.5 Kg.). In each of the remaining 4 hips a Smith-Petersen nail was introduced, and the average refracture force was 348 pounds (156.5 Kg.). The threaded wires compared favorably with the larger nail or pins in resisting breakdown force. Holding or distraction force was also measured by calculating the force in pounds required for pulling the head and neck apart at the line of fracture after pinning with the Smith-Petersen nail, three Steinman pins or three threaded wires inserted in the usual criss-cross fashion. This distraction force averaged 50, 87 and 116 pounds respectively (22.5, 39 and 52 Kg.). The authors found the average breakdown force of hips pinned with wires in the transverse position to be 726.6 pounds (327 Kg.), as compared with that of the contralateral hips pinned with obliquely placed wires, which was 452 pounds (203.5 Kg.)—a difference of 271 pounds (122 Kg.).

The authors concluded that the holding power of three small threaded steel wires is greater than that of the Smith-Petersen nail or of larger nonthreaded Steinman pins. Small threaded nuts on each wire may be tightened securely against the lateral cortex of the femur to prevent migration. The authors felt that the insertion of threaded steel wires produced minimal trauma to cancellous bone and were unlikely to injure nutrient blood vessels since they constitute no real obstruction to revascularization. They have used this method successfully both in the treatment of recent fractures of the neck of the femur without casts and with almost immediate ambulation and also in conjunction with tibial bone grafts in the treatment of old ununited fractures of the neck of the femur, and they did not find it necessary for immobilization. They state that this method is mechanically efficient because it is believed to be physiologic, relatively atraumatic and less likely to contribute to delayed aseptic necrosis than methods requiring grosser trauma and greater displacement of cancellous bone of the fractured fragment.

Thomas [561] discusses the end results of screw fixation in the treatment of intracapsular fractures of the femoral neck. After reduction he used Whitmann's abduction–internal rotation cast and operated through a window overlying the greater trochanter. He states that after incision a finger may be pushed anterior to the trochanter to determine the direction of the neck and a carpenter's screw may be introduced ½ inch (1.27 cm.) below the margin of the trochanter. The second screw may be introduced just below the first far enough so as not to overlap the head of the upper screw. The patient remained in the cast for ten days and generally had a satisfactory result. No infections occurred, and there was only 1 instance of nonunion, which was due to the screws' being too long. After removal of the two screws and the introduction of a third screw, this patient still had nonunion with aseptic necrosis. One patient because of a second fall had a refracture through the screws, but after introduction of another screw union occurred. The author states that satisfactory results may be obtained by this method.

561. Thomas, T. T.: End Results of Screw Fixation in Intracapsular Fractures of Neck of Femur, Am. J. Surg. **57**:65-75 (July) 1942.

Fitzgerald and Clark [562] describe a combined film holder and pelvic rest which helps achieve accurate, rapid and clear roentgenograms during operations for fractures of the femoral neck. The apparatus holds the film steadily or at the correct angle and in the same position for each exposure. The x-ray film may be removed from the opposite side of the table from the operator. [ED. NOTE.—The apparatus appears to be simple and practical.]

Cleveland [563] reviews 110 fractures of the femoral neck treated during a decade extending from 1930 to 1940. The first 50 patients were treated by manipulation and application of a plaster of paris spica or traction in a few instances. Fourteen per cent of these patients died as a result of the fracture, and 61 per cent had nonunion. In 1935 internal fixation was first used with open reduction, and of the 14 patients treated in this fashion only 7 or 50 per cent obtained union, and in only 2 of these was the result wholly satisfactory.

In the second group, of 60 patients, 52 were treated by open reduction and 8, who had undisplaced fractures, were not operated on. The 8 who were not operated on all had healing without evidence of condensing osteitis of the femoral head or aseptic necrosis. The three phalange nail was used in all cases in which operation was performed. In 3 of the cases nonunion and extensive aseptic necrosis developed, and in 2 there was bad nonunion with pronounced deformity. In some cases of open reduction there developed overgrowths from the acetabular margins, perhaps due to stripping of the periosteum. Closed reduction and internal fixation were carried out for 37 patients; in 27, or 73 per cent, union resulted, but 4 had slight condensing osteitis and 1 advanced aseptic necrosis. Twenty-five, or 86 per cent, of this group are living and have union. Cleveland states that adequate reduction and internal fixation result in a high percentage of union. Of the 38 patients treated by closed reduction and internal fixation, 26, or 68 per cent, had almost perfect reduction, and in 6, or 16 per cent, the fracture was reduced so that bony apposition was 75 per cent or better. In 5 there was malunion, with resulting deformity. In 2 of the cases of malunion there were circulatory changes in the femoral head. Cleveland states that the most important cause of such circulatory disturbance has been failure to reduce the fracture and keep it reduced. He also points out that actual or so-called migration of the nail is usually due to improper reduction and that migration occurs almost exclusively in ununited fractures. Patients with nonunion may be benefited by a trochanteric osteotomy. In his series accurate reduction of a fractured neck of the femur by manipulation and fixation by a properly placed three phalange nail resulted in unions in a high percentage of patients, and 86 per cent survived with only a low incidence of circulatory disturbance in the femoral head. [ED. NOTE.—This is an excellent review of an important subject.]

Brittain [564] describes internal fixation with a three phalange nail for treatment of trochanteric or extracapsular fractures of the femur. He mentions that treatment of trochanteric or basal fractures of the neck by traction on a Thomas splint or by a plaster of paris spica is extremely difficult and requires skilled nursing and constant attention of the surgeon. The disadvantages of nailing this type of fracture are presented: The operation is difficult because the cortical bone splinters into the fracture; it is a more formidable operation than the medial nailing requiring a more extensive exposure, and the fracture generally unites in any event. His operative technic and after-treatment are described. He states that splintering can be controlled by making a furrow with a gage extending 1½ inches (3.8 cm.) downward from the trochanteric edge and just wide enough to admit the phalanges of the nail and not the head. Fractures of the shaft below the site of insertion of the nail occurred in 2 patients as a result of a fall but subsequently united uneventfully. He states that rotation deformity cannot occur

562. Fitzgerald, F. P., and Clark, K. C.: Radiography of Femoral Neck, Lancet **2**:183-184 (Aug. 15) 1942.

563. Cleveland, M.: A Critical Survey of Ten Years' Experience with Fractures of the Neck of the Femur, Surg., Gynec. & Obst. **74**:529-540 (Feb., no. 2A) 1942.

564. Brittain, H. A.: Low Nail, Brit. M. J. **1**:463-464 (April 11) 1942.

because of the position of the nail but that adduction deformity occurred in 3 patients, explained on the basis that the nail was not long enough. He states that a hold of 2 inches (5 cm.) in the upper fragment and 2 inches in the lower should be enough to hold the fragments. During the two years prior to July 1941, between 40 and 50 patients had trochanteric fractures nailed, with good results in over 75 per cent of the cases.

Plummer and Potts [565] discuss end result of the treatment of approximately 125 fractured hips by means of internal fixation. Kirschner wires were first used but were found to be unsatisfactory. Moore pins were used with satisfaction, but in the last few years three phalange nails were used. All fractures of the femoral neck were treated by manipulation and internal fixation irrespective of the patient's age or the presence of a complicating lesion. The authors state that the more simple, impacted transcervical fracture is just as much entitled to this form of treatment as the fractured neck with marked separation of the fragments. Difficulty of reduction, inability to maintain the reduction and failure of the nail to get a firm grip in the proximal portion of the neck and head were thought to be due to obliquity of the line of fracture. The authors felt that this constituted one cause of failure. If a valgus position was obtained, slight unreduced rotation was not changed, and it was not believed to be a factor in the unfavorable results. The authors felt that a 75 per cent approximation of the neck to the head would allow for adequate placing of the nail and would give a satisfactory result. They also felt that impaction was not logical or practical and that internal rotation produced sufficient impaction without further damage to the blood supply. One difficulty encountered was protrusion of the nail through the upper part of the head, which occurred when the position of the nail in the head was high. They felt that the best position for the nail was in the center of the head or slightly below, with the arm of the Y toward the upper portion of the head. Some patients experienced pain at the end of ten days. In their cases roentgen examination showed the nail backed out or the head disengaged from the nail. It was felt that this occurred when the fracture line was oblique or the fracture was comminuted. Aseptic necrosis of the femoral head occurred in a case in which the fracture was easily reduced and the reduction was maintained. Two patients had nonunion without aseptic necrosis, and after open reduction with the removal of scar tissue at the fracture line satisfactory results were obtained. Two failures were reported with this same procedure where the heads were necrotic. The authors have also noted that after satisfactory reduction and nailing protrusion of the nail and definite changes in the relations of the head and neck were present a year later. Here, they point out, the interpretation of satisfactory union made roentgenographically was incorrect. They allowed the patients to bear weight only after trabeculations could be seen across the fracture line. The authors feel that failures are due in part to the operators and in part to circulatory changes occurring at the time of fracture.

West [566] discusses the treatment of slipped upper femoral epiphyses and divides the patients treated into five general groups. The patients in whom the deformity is so slight that reduction is not necessary were treated by simple fixation and protection, either by plaster or by the Thomas caliper walking splint. The patients in whom the injury was of recent origin and the deformity mild were treated by manipulation under anesthesia. It was felt that this could be carried out without damage to the femoral head. The patients in whom the deformity was further advanced and union was more definite were treated by simple osteotomy with a large wood carver's chisel through the epiphysial line, followed by proper protection. The author states that for the patients in whom the union was solid and the neck showed a typical torsion as the result of malunion the best treatment was by osteotomy and proper maintenance of position. Some of these patients

565. Plummer, W. W., and Potts, F. N.: Some End Results of Internal Fixation of Hip, New York State J. Med. **42**:997-999 (May 15) 1942.

566. West, W. K.: The Treatment of Slipped Upper Femoral Epiphyses, South. M. J. **35**:1082-1085 (Dec.) 1942.

were treated by manipulative reduction and the insertion of a three phalange nail. The author points out the difficulty of proper placement of the nail in a child and the danger of the nail's penetrating the hip joint proper. For the fifth group of patients, in whom the deformity was severe, union solid, the head widened and the neck thickened, subtrochanteric osteotomy was carried out for correction of the rotation and improvement of the coxa vara, which resulted in an increased range of abduction. There were 42 cases in the author's series, who were treated over a period of eleven years. He points out that skeletal traction prior to open reduction may prove beneficial. He states that when even expert orthopedic surgeons use the Smith-Petersen nail there is danger of damage to the necrotic head. He believes that an arthroplastic procedure should be done rarely, because of shortening the leg, instability and the possibility of a permanently painful hip. Ten case reports are given in detail.

If the Smith-Petersen nail and similar devices are to be placed on a surer basis, Bankart [567] indicates some points which seem to call for further consideration. He discusses the selection of cases and points out several feasible contraindications for nailing. He feels that in some instances it is better to do a transtrochanteric osteotomy at once rather than to wait for failure of a nailing operation. He recalls that the impacted subcapital abduction fracture always heals with bony union if it is treated in a short plaster spica that permits the patient to walk; he suggests that weight bearing on an impacted fracture is not in itself harmful so long as the joint is not moved, and he considers whether this has any bearing on the treatment of adduction fractures after internal fixation and questions whether in fact the nailed adduction fracture should not be treated in the same way as the impacted abduction fracture, in a short, ambulatory plaster spica. When fractures unsuitable for nailing have been eliminated, the principal causes of failure are: imperfect reduction of the fracture, faulty application of the nail and inappropriate after-care. For reducing the fracture he feels that well leg traction is the best method, as the device can be adjusted at leisure and when the reduction is perfect the patient can be lifted safely onto the operating table with the traction apparatus still on the limb. In inserting the nail, he points out that the more vertically the nail is placed the less will be the breaking strain across it and the more will the proximal fragment be guided toward and pressed against the distal fragment by pressure from above. He states that the best angle for the nailing is one of 140 degrees with the long axis of the shaft of the femur. He points out that it must be remembered that a nail can hold fragments apart as well as hold them together. He feels that the common practice of forbidding weight bearing for some months after the operation while encouraging active movement of the hip should be reconsidered, and he gives reasons for believing that early weight bearing should be encouraged while movement of the hip should be prevented until bony union has taken place. He outlines his technic for the nailing operation and points out the importance of anchoring the proximal fragment to the pelvis while the nail is being driven in, in order to avoid displacement of the head by the oncoming nail. [ED. NOTE.—The article is timely and contains many excellent suggestions.]

Cochrane [568] refers to the recent developments in the treatment of fractures of the femoral neck and to the fundamentals of their management. He reviews statistics on results of the treatment of such fractures by external fixation through the medium of the plaster hip spica and by internal fixation with the Smith-Petersen nail, finding the incidence of nonunion, 12 per cent to 15 per cent, to be approximately the same by both methods in the series cited. He does not advocate the use of the plaster fixation method routinely. He notes the points to be considered in selecting cases for its employment, such as the exact site of the fracture in the neck, the mechanism of its production, the resultant "fracture-shaft angle,"

567. Bankart, A. S. B.: Treatment of Intracapsular Fractures of Femoral Neck, Lancet **1**:249-252 (Feb. 28) 1942.

568. Cochrane, W. A.: Flexed Plaster Spica for Fractured Femoral Neck, Lancet **2**:726-728 (Dec. 13) 1941.

the time interval since injury and the facilities available for internal fixation. The main differences between the author's method and that of Whitman, advocated forty years ago, are: (1) roentgenograms taken in two planes, to prove reduction, the great importance of which he emphasizes; (2) immobilization of the hip in flexion of from 50 to 60 degrees, rather than in extension, and in relatively less abduction, about 20 degrees from the midline, (3) careful application of the spica, to attain lightness and close fit.

Dudgeon [569] reports a treatment of fracture-dislocations about the pelvis that consists in (1) application of full length leg plasters, (2) incorporation of turnbuckles into the medial aspects of the leg plasters at the proximal level and the ankle level and (3) correction of pelvic displacements by manipulation of turnbuckles.

The results of treatment of 2 patients are reported. One, with compression of the pelvis and protrusion of the femoral head through the acetabulum, obtained excellent reposition, while the other, with wide separation of the symphysis and dislocation of the sacro-iliac joint, obtained a reduction of the symphysis but no improvement of the sacroiliac dislocation.

Funsten, Frankel and Harris [570] report 2 cases of unusual traumatic dislocation of the hip. The first is the case of a 49 year old man with upward displacement of a fragment from the superior rim of the acetabulum and the femoral head, in whom the fragment eventually formed a solid shelf which allowed full weight bearing eleven weeks after injury. The hip was stable and painless and exhibited an excellent range of motion. The second case is that of a 24 year old Negro in whom an axe wound of the hip, incurred twenty hours before his admission to the hospital, resulted in a fracture of the greater trochanter with displacement, laceration into the femoral head and lateral anterior and superior dislocation. Immediate débridement, reduction, fixation of the trochanter with wire, closure with drains and local implantation of a sulfonamide compound were done. Healing was by first intention; motion was started nine weeks later, and full weight bearing was permitted eighteen weeks after the reduction. Examination twenty-five weeks after the patient's injury showed no limp and a painless hip with good motion except in flexion, which was limited to 50 degrees. The danger of closing this wound twenty hours old was weighed against the adverse effect of leaving the joint open. The authors plan to wait for longer follow-ups before evaluating end results.

Hart [571] reports a case of severe fracture-dislocation of the hip in a 46 year old man, associated with a compound fracture of the patella in the same extremity. The latter condition was treated immediately by the usual methods, with excision of the entire fragmented patella. Primary closure was done and healing was obtained without infection. One month later the hip was treated by the method advocated by Watson-Jones, excision of the loose and displaced femoral head, followed by a Whitman reconstruction, the neck of the femur being placed in the joint. Plaster immobilization was employed, with the extremity maintained in the position of election. The convalescence was uneventful. Ankylosis of the hip in good functional position resulted.

Romney,[572] after a critical survey of the various operations devised for fracture of the neck of the femur, enumerates the advantages of the Godoy Moreira method: (1) The screw has a helicoid thread resembling the Danis screw but is deeper and sharper, so that an excellent hold on the femoral head is afforded; (2) tests showed that this nail required 251 Kg. to bend it and 317 Kg. to rupture it, pressures two or three times those tolerated by nails and pins of other types;

569. Dudgeon, H., Jr.: Pelvic Fractures and Dislocations Reduced by Turnbuckles, J. Bone & Joint Surg. **24**:354-358 (April) 1942.

570. Funsten, R. V.; Frankel, C. J., and Harris, L.: Two Unusual Traumatic Dislocations of Hip, J. Bone & Joint Surg. **24**:443-446 (April) 1942.

571. Hart, V. L.: Fracture-Dislocation of Hip, J. Bone & Joint Surg. **24**:458-460 (April) 1942.

572. Romney, H.: Treatment of Fractures of Neck of Femur Using the Technique of Godoy-Moreira, Rev. de med. y cir., Habana **46**:547-571 (Dec. 31) 1941.

(3) it is not necessary to use a hammer to insert the screw; (4) the screw will not slip inward or outward; (5) the firm hold prevents trophic disturbances due to malnutrition; (6) the solidity obtained is superior to that of the normal femoral neck and permits early ambulation without crutches or other support (walking was possible between the seventh and the twelfth day in the author's cases). [ED. NOTE.—The Godoy Moreira technic is described by Godoy Moreira himself in an article in the *Journal of Bone and Joint Surgery.*] [573]

Sosa [574] presents a new type of graft-bearing nail for use in the treatment of transcervical and subcapital fractures of the neck of the femur. This graft, in his opinion, solves the biologic problems of repair of fractures. The nail has four phalanges for the cephalic fragment; a middle portion, also with four phalanges, which is narrower, for incrustation with the graft, and an outer portion, a threaded pin to receive the head to be screwed thereon, to fasten in the cortex of the trochanter. The bone graft is cut the same length as the middle portion of the nail and drilled. The nail is introduced into it and the head screwed on and fixed with a wedge, when everything is ready for nailing. [ED. NOTE.—One editor (L. D. B.) does not consider this the final achievement and believes that better means of fixation will be developed for fractures of the femoral neck.]

Hoffheinz [575] reports a series of 161 cases of nailed fractures of the femoral neck. He discusses indications, preoperative treatment and operative technic. In this series the mortality rate was 9.9 per cent, as compared with 14.6 per cent in the author's earlier series. He does not believe that nailing is indicated for young subjects, in whom healing usually takes place. However, if conservative measures fail, nailing may be tried. The average age of the patients whose fractures were nailed was 68 years, and the oldest patient was 92.

In fractures of the trochanter, the trochanter is so involved that there is not sufficient solid bone to hold the nail. As a rule the author waits for eleven days after the accident before operating. The use of two roentgen apparatus is preferable, facilitates operation, increases asepsis and also precludes confusion from incorrect projection of the bundle of rays. The guide wire must be strong enough not to bend and should almost fill the nail canal. The failure to accomplish exact reduction does not necessarily mean an unsuccessful operation. The author disapproves of guiding instruments. The nail must be driven in until the head lies well within the cortical layer. The length of the nail is chosen so that the tip of the nail lies 1 cm. from the cartilage covering of the head. Since the author has closed the nail canal surrounding the wound in the bone with wax, the number of postoperative hematomas has diminished considerably.

After nailing necrosis usually does not develop until after a period of years of respite, whereas after conservative treatment if necrosis does develop it usually occurs much earlier and the patient never walks again. The few years of respite are valued by these old people.

XX. FRACTURE DEFORMITIES

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Hermann, Reineke and Caldwell [576] supplement previous reports by Hermann and Caldwell in an article in which they reaffirm and elaborate on their previously expressed ideas regarding the causation, roentgenologic characteristics and treat-

573. Godoy Moreira, F. E.: Special Stud-Bolt Screw for Fixation of Fractures of Neck of Femur, J. Bone & Joint Surg. **22**:683-697 (July) 1940.

574. Sosa, U.: Graft-Carrying Transcervical and Subcapital Fractures, Cir. ortop. y traumatol., Habana **9**:88-97 (April-June) 1941.

575. Hoffheinz, S.: Fractures of Neck of Femur: Modern Therapy; Critical Study, Arch. f. klin. Chir. **201**:584-596, 1941.

576. Hermann, L. G.; Reineke, H. G., and Caldwell, J. A.: Post-Traumatic Painful Osteoporosis: Clinical and Roentgenological Entity, Am. J. Roentgenol. **47**:353-361 (March) 1942.

ment of post-traumatic painful osteoporosis. The authors prefer this term rather than acute osseous atrophy, as they feel that it more nearly portrays the clinical and pathologic character of this disease entity, which is manifest as a patchy demineralization of bone associated with coexisting signs of vasomotor instability, trophic changes in the soft tissues and pain. Disturbance in function is always greater than is to be expected from the trauma alone.

Three types are differentiated: (1) osteoporosis following minor trauma about one of the polyarticular regions, such as the wrist or the foot; (2) osteoporosis following trauma sufficient to produce fracture, usually about a joint, and (3) osteoporosis associated with minor traumatic disturbances in which tendons or periarticular structures appear to be first involved, with the typical changes in the bone.

Early adequate treatment is insisted on by the authors if severe and prolonged disability is to be avoided. They do not feel that any of the conservative methods of treatment commonly used, such as immobilization, various forms of physical therapy or active use, materially affects the course of the disease. Roentgen therapy, as recommended by Mumford, reduces the pain, but in 18 patients on whom the authors tried it they found that the destruction of bone continued and the disturbance in function was unaltered. Removal of or making injections into the sympathetic ganglions is not successful, because the disease is produced by disturbed function in the neurotrophic fibers lying in the adventitia of the major artery supplying the part, and these fibers do not pass through the sympathetic ganglions. Periarterial sympathectomy, suggested by Heyman, has given the only reliable results in the authors' opinion. They report 34 cases of periarterial sympathectomy with excellent results and recommend this as the treatment of choice.

Miller and de Takáts,[577] after an exhaustive review of the various anatomic and physiologic factors relating to post-traumatic dystrophy (painful osteoporosis), offer certain explanations regarding the causation and suggestions as to the treatment which are at considerable variance with those expressed in the preceding article.

They conclude that careful examination in the early stages of post-traumatic dystrophy will reveal a source of continuous nerve stimuli which are responsible for the sensory and vasomotor phenomena. The evidence regarding the origin of these painful stimuli is at present controversial and somewhat contradictory. The vasomotor dilatation with increased blood flow through the extremity is a well recognized phenomenon in the early stages of traumatic osteoporosis. Sympathetic block, which also produces vasodilatation, definitely relieves the pain and produces clinical improvement. This apparent contradiction may be explained by an incomplete understanding of the transmission of pain impulses through the sympathetic nervous system.

Whatever the explanation, prevention of pain by complete fixation of injuries with repeated sympathetic block in the earlier stages and sympathectomy in the more intractable cases has been of decided benefit.

[ED. NOTE.—While there can be no argument that post-traumatic painful osteoporosis always produces severe and prolonged disability and sometimes permanent deformities and loss of function, it is equally true that most of the patients recover with, or in spite of, some form of conservative treatment. It is not always possible in the early stages of the disease to determine whether or not it is going to be of the intractable type. Neither periarterial sympathectomy nor sympathetic ganglionectomy is a minor surgical procedure, and the ultimate effects of these operations are not thoroughly understood. Since authors who have admittedly given this subject as intensive study as any authority differ so widely in their published opinions regarding the results of treatment, it does not appear that such radical measures are yet justified by the evidence presented.]

577. Miller, D. S., and de Takáts, G.: Post-Traumatic Dystrophy of Extremities: Sudeck's Atrophy, Surg., Gynec. & Obst. **75**:558-582 (Nov.) 1942.

Clinical observation has added little in recent years to the knowledge of formation of callus and healing of fractures. One expectantly looks to the field of biochemistry for future help in explaining this commonplace yet still obscure physiologic process. The apparent paucity of practical results gained from this field of experimental medicine has not discouraged those interested in the subject, and each year the results of new work published add positive or negative facts to the gradually accumulating data.

Armstrong, Sperling and Litow [578] report the results of the use of sodium betaglycerophosphate in connection with the healing of experimental fracture in rabbits. Although the phosphatase activity of a fracture callus increases rapidly during the first few days after the injury, there is no evidence that defective calcification or delay in healing of a fracture is primarily a result of a quantitative deficiency of this enzyme.

While the erythrocytes are high in phosphoric esters hydrolyzable by phosphatase, the blood plasma is relatively low. The authors felt that one of the factors limiting the speed of the calcification process might be the low content of plasma with respect to the substrate of bone phosphatase, and this consideration suggested that some instances of delayed union or nonunion of fractures might be so explained.

Twenty-seven rabbits with experimental fractures received six to fourteen daily intravenous injections of 0.1 Gm. of sodium betaglycerophosphate. All the animals were killed the day after the last injection. Examination of the sites of fracture grossly and by roentgenograms revealed a larger amount of callus in the animals that had received injections than in the control group. The observations indicated that in the majority of cases the drug exerted a positive effect in increasing the rapidity and amount of callus formation. Four determinations of inorganic phosphate and calcium in the serum made at regular intervals during the course of twelve daily injections showed no consistent differences from values in the untreated animals.

Since sodium betaglycerophosphate is harmless in a wide range of dosage, it should be safe to administer it to human beings in order to determine its effect on those fractures which heal at a rate slower than usual.

Rhoads and Kasinkas [579] investigated the effect of hypoproteinemia on the formation of callus in experimental fractures. Hypoproteinemia has been shown to retard the healing of wounds of soft tissues in experimental animals. The authors' study was made to determine if it might also exert an adverse influence on the healing of fractures.

In a small series of dogs hypoproteinemia was produced by a low protein diet and by repeated plasmaphoresis. Experimental fractures in this group of dogs showed a consistent delay in healing as compared with the control series.

The rationale back of their experiment was based on the accepted fact that a large portion of the serum calcium is bound to the serum protein, so that when serum protein is low serum calcium is also reduced. Sufficient clinical data are not available to warrant the assumption that hypoproteinemia is a factor in delayed union or nonunion of fractures in human beings.

In spite of the extensive clinical experience indicative that sulfonamide compounds do not interfere with the healing of wounds in soft tissues or exert any inhibiting action on callus formation, there is still considerable opposition by many surgeons to the local implantation of those drugs in wounds. Some of this opposition is probably based on such experimental work as that of Veal and Klepser,[580]

578. Armstrong, W. D.; Sperling, L., and Litow, S.: Effect of Phosphoric Acid Esters on Fracture Healing, Proc. Soc. Exper. Biol. & Med. **49**:169-171 (Feb.) 1942.

579. Rhoads, J. E., and Kasinkas, W.: Influence of Hypoproteinemia on Formation of Callus in Experimental Fracture, Surgery **11**:38-44 (Jan.) 1942.

580. Klepser, R. G.: Problems in the Local Use of Sulfonamides, M. Ann. District of Columbia **11**:211-213 (June) 1942.

who noted a deleterious effect of powdered sulfonamide compounds on normal cellular activity, and on pathologic studies on rats by Davis, Harris and Schmeisser,[581] who observed a nonspecific foreign body reaction to crystalline sulfonamide compounds.

Horwitz [582] reviews the literature pertaining to the controversy and adds both experimental and clinical data to prove that sulfonamide compounds in powder form have no adverse effect on healing of bone or on the fate of transplanted bone. In experiments with adult rabbits bone grafts were transplanted from the iliac crests to the tibia and from one tibia to the other. Sulfanilamide or sulfathiazole crystals were implanted in the wounds of one group, and for a similar control group no drug was used. The bones operated on were removed at intervals of one to eight weeks for roentgenologic and microscopic study. Grossly and roentgenologically the transplanted grafts were solidly united to the host bone in four weeks, there being no demonstrable difference between the treated and the control group. Microscopically the grafts in both groups passed through the usual stages of necrosis and vascular resorptive substitution with fibrous tissue in which new bone was formed. The only difference noted in the two groups was that in the wounds in which the sulfonamide drugs were implanted the fibroblastic reaction of the paraosseous tissues appeared excessive. In 5 clinical cases in which grafts were transplanted into infected or potentially infected areas in conjunction with local implantation of a sulfonamide compound the wounds healed by first intention and progress of the graft in the various procedures of union appeared normal.

[ED. NOTE.—Clinical experience of one editor (J. S. S.) and of hosts of other surgeons in many hundreds of cases amply substantiates the conclusions just cited. Local implantation of sulfonamide compounds in operative wounds does not produce any undesirable reaction, and its bacteriostatic action permits a much bolder and earlier surgical solution of many infected or potentially infected nonunions. Flare-ups of low grade infections still occur after such operations, but it is extremely rare to see the severe fulminating recurrences of infection with sloughing of the soft tissues and sequestration and loss of the graft which used to be seen. Sterilization of the drug is apparently unnecessary.]

Some interesting ideas regarding the behavior and fate of transplanted cartilage and bone are given by Mowlem [583] in reviewing a series of such grafts utilized chiefly in repairing defects of the ear and nose. Transplanted costal cartilage, which is a relatively avascular structure, does not undergo absorption even after a period of years. Grossly the graft changes little in size or shape, there being only slight evidence of cellular growth, although microscopically the cellular structure of the transplant appears relatively normal. Mowlem states that there is a wealth of literature on the subject of survival of bone, and a corresponding great diversity of opinion. After reviewing the various theories, the author concludes that with the exception of that of Leriche and Policard, the conflicting ideas may not be wholly irreconcilable. It seems probable that the bone cells in a transplant have the power of survival but that this is dependent on the rapidity with which they can acquire nutriment in their new position. The nutriment will, as in the case of other grafted tissue, first be derived from blood serum and tissue fluid and only later be supplied by the ingrowth of any real vascular supply. The structure of the bone determines to a great extent the accessibility of the enclosed cellular element to this nourishment. This will vary considerably between dense cortical tibial grafts and a piece of cancellous ilium.

Mowlem stresses two other points which appear to bear out the suggestion that an early and adequate nutritional supply is essential to the actual survival

581. Davis, H. A.; Harris, L. C., and Schmeisser, H. C.: The Toxic Effect of Sulfanilamide Upon Tissues of Rats, J. Lab. & Clin. Med. **25**:1263-1275 (Sept.) 1940.

582. Horwitz, T.: Effect of Sulfanilamide Crystals, Used Topically on Fate of Transplanted Bone: Some Experimental and Clinical Observations, Surgery **11**:690-697 (May) 1942.

583. Mowlem, R.: Bone and Cartilage Transplants: Their Use and Behavior, Brit. J. Surg. **29**:182-193 (Oct.) 1941.

of the graft. If cancellous iliac bone is placed in the fatty tissues of the abdominal wall it will rapidly atrophy, but if placed in the vascular tissues of the face it may hypertrophy and form a new cortical covering of normal cortical architecture. The second point is that epiphysial bone and epiphysial cartilage show considerably more tendency to be absorbed than more mature structures. One assumes that this is due to the fact that the bone cells, being younger and more active, have a higher metabolic rate and therefore do not survive even the short transitional period during which their nutrition is absent.

Further data in reference to regeneration of bone and the viability and regeneration of partial or complete joint transplants are contained in an article by May.[584] He summarizes his own experimental and clinical conclusions and the experience of others as follows: Transplantation of whole joints with their capsules, either homogenous or autogenous, has been discouraged, particularly in weight-bearing joints, because of degeneration or ankylosis due to incomplete revascularization and resultant necrosis. Homogenous hemitransplants have proved unsatisfactory for the same reasons. Autogenous hemitransplants have proved to be relatively good, particularly smaller bones, such as the fibula for replacing the upper end of the humerus or the lower end of the radius. In these the bone undergoes a primary necrosis, just as occurs in bone grafts with later regeneration, by a process of substitution and new bone formation. The outer layers of the articular cartilage remain viable, and the deeper layers undergo partial necrosis, but all these cartilage cells later become completely viable if the bone is revascularized within a year's time. The author reviews the present data regarding the revascularization and regeneration of the articular fragment in such fractures as intracapsular fractures of the femoral neck and carpal scaphoid and points out the biologic similarity of the healing of such fractures to that following hemitransplantation of joints.

Transplantation of portions of a bone containing an active epiphysis universally results in cessation of epiphysial growth. [ED. NOTE.—Transplantation of the fibula, including its upper articulation, has been employed successfully for many years in non-weight bearing joints. It has not been satisfactory in replacing the external malleolus in congenital absence of the lower end of the fibula, probably because the operation is necessarily done at an age when the epiphysis is still active and because it forms part of a weight-bearing joint. This same principle accounts for the unsatisfactory results in the correction of malunions in which it is necessary to mobilize completely joint fragments containing actively growing epiphyses, such as malunited fractures of the humeral condyles in children. Mowlem's observation, previously cited, that neither young epiphysial bone nor actively growing cells at the epiphysial plate could withstand even temporary loss of nutriment through interruption of their blood supply is fully corroborated by clinical experience.]

Milch [585] reports the use of a fibular graft replacing the lower end of the radius after resection for a giant cell tumor. The lower end of the fibular transplant was fixed to the carpal scaphoid by arthrodesis, and a cuff resection of the lower portion of the ulna was done to permit rotation of the forearm. The functional result was good except for loss of motion of the wrist. [ED. NOTE.—A somewhat similar operation has been successfully employed by one of the editors (J. S. S.) in 4 cases of giant cell tumor of the lower end of the radius, in which both motion and stability of the wrist joint were retained. The upper articulation of the fibula with the tibia closely resembles in shape the lower articulation of the radius. It is also covered with hyaline cartilage. A sufficient length of the upper end of the fibula with its articulation is resected and transplanted to replace the resected portion of the radius, the previous tibiofibular articulation forming the new radio-

584. May, H.: Regeneration of Joint Transplants and Intracapsular Fragments, Ann. Surg. **116**:297-310 (Aug.) 1942.

585. Milch, H.: Forearm Reconstruction Following Partial Resection of Radius, Bull. Hosp. Joint Dis. **3**:100-104 (July) 1942.

carpal joint. Possible degeneration of the articular cartilage with a resultant painful arthritis has not been reported observed by others or noted in personal observation in 1 case as long as four years.]

Rothberg [586] emphasizes the importance of greater diagnostic care when a fresh fracture of the carpal scaphoid is suspected. The clinical signs and symptoms should receive more emphasis and the roentgenographic less. An initial roentgenogram with no evidence of a fracture does not necessarily rule out the possibility of one. Several variations from the usual technic may be employed when the ordinary anteroposterior and lateral views fail to reveal a fracture. Views should be taken with the hand in ulnar deviation and with two exposures, the one with a tube shift a little to the right and the other to the left. In some cases in which a fracture line cannot be demonstrated at the time of the initial fracture, roentgenograms taken weeks later may reveal the site of fracture, brought to light by the process of osteoporosis.

In a second article, discussing the treatment of ununited fractures of the carpal scaphoid, Rothberg [587] recommends simple drilling followed by ten weeks of immobilization in a cast. He states that this method is not applicable in all cases and enumerates other procedures, such as removal of all or part of the scaphoid, resection of the entire proximal row of carpals and fusion of the wrist, as sometimes necessary. [ED. NOTE.—The whole problem of fractures of the carpal scaphoid lacks much of having a satisfactory solution at the present time. Early recognition of these fractures by familiarity with the clinical manifestations and by the use of special roentgenologic views will help in reducing the number of cases of nonunion. Even with early recognition and the present methods of treatment there will still be too many instances of nonunion or union with aseptic necrosis, producing serious permanent disability. It would seem that the difficulties attendant on the treatment of the fractures closely simulate those of central fractures of the neck of the femur. Complete immobilization of the fragments by some means of internal fixation at the time of the acute fracture, permitting early revascularization, may improve the results.]

Under the title "Epiphyseal Pseudarthrosis," Milch [588] describes an interesting condition whose recognition he feels may be of some value in explaining both the apparent failure of certain hip fusion operations and the mechanism of development of so-called coxa anteverta or the early phase of adolescent epiphysial separation at the upper end of the femur. Epiphysial pseudarthrosis has been observed under the following conditions: (1) after operative fusion of the hip, (2) after inflammatory ankylosis of the hip and (3) as a sequel to adolescent epiphysiolysis. It may occur in any hip in which the capital epiphysis becomes ankylosed before the epiphysial plate closes. The condition manifests itself as a false joint between the neck and the capital femoral epiphysis. The mechanical explanation for this in cases in which the head is fused to the acetabulum is readily understood, but in cases of adolescent epiphysiolysis, in which the capital epiphysis is freely movable, other factors must be considered. The author offers an interesting hypothesis to explain pseudarthrosis associated with adolescent epiphysiolysis and also adolescent epiphysiolysis itself. Forces which amplify external rotation of the femoral shaft, such as overweight, trauma and conditions which decrease the resistance of the cartilage plate, for instance endocrine and other metabolic disturbances, have been proposed as causative factors, but the author states that any valid description of the mechanism must include a force which would act on the head in a direction contrary to that made necessary by the progressive anteversion of the upper end of the neck. The author believes that such a force is provided by the tendon of the iliopsoas muscle as it passes over the anterior portion of the capsule of the

586. Rothberg, A. S.: Fractures of the Carpal Navicular, J. Bone & Joint Surg. **21**:1020-1022 (Oct.) 1939.

587. Rothberg, A. S.: Ununited Fractures of Carpal Scaphoid, Am. J. Surg. **56**:611-613 (June) 1942.

588. Milch, H.: Epiphyseal Pseudarthrosis, J. Bone & Joint Surg. **24**:653-662 (July) 1942.

hip joint. The iliopsoas tendon does not lie over the head and neck of the femur but extends only over the descending arm of the Y ligament of Bigelow. In external rotation, in which the anterior portion of the femoral head is directed forward, it is seen that the iliopsoas tendon is opposed against only the epiphysial portion of the head. The limit of external rotation appears to be limited not by the capsule per se but by the resistance or torsion of the iliopsoas tendon. This disposition of the psoas tendon offers a rational anatomic explanation for the development of the counterforce necessary for the production of epiphysiolysis.

Ghormley,[589] in a careful analysis of the types and uses of bone grafts, gives some instructive data on his experience with homogenous grafts. In certain instances in which a satisfactory graft cannot be obtained from the patient the use of a graft from another person is a sound surgical procedure. While theoretically it is advantageous to obtain the graft from a close relative, or at least from a donor of the same blood group, practically it appears to make little difference. Ghormley reports 10 successes in 18 operations with homogenous grafts, 3 of the failures being in congenital pseudarthrosis. [ED. NOTE.—Since the introduction of the dual type of homogenous graft Boyd, Henderson and others have reported unions in congenital pseudarthrosis in the same percentage as other types of nonunion. In 1 of Boyd's successful cases the graft was taken from a father by adoption, and there was no blood relationship.]

Abbott and Gill [590] review the use of iliac grafts for shelves and fusions of the hip and emphasize the advantages of such cancellous grafts to promote union in other locations. Grafts from the ilium are easily accessible, are rapidly revascularized, contain an abundance of osteogenic material and possess sufficient stability to be used in many locations. The grafts may be removed from different locations on the ilium, depending on the size and shape of the graft desired. They are especially useful in filling angular defects following osteotomies and in maintaining the corrected elevation in depressed fractures of the tibial condyles. The authors believe that because of their cancellous nature iliac grafts are more rapidly revascularized and revitalized than tibial grafts. While they do not possess the stability of tibial grafts, grafts from the crest of the ilium are sufficiently strong to be used in many locations where it is not customary to use tibial grafts. The authors' experience with grafts of this type over a period of twenty years justifies their advocating its more general use.

Leavitt [591] reports the unusual occurrence of three ununited fractures of the ribs in a patient with an adherent diaphragm. The author suggests that it would require some such unusual fixation of part of the wall of the chest to permit sufficient separation of the fragments to produce nonunion. The sites of nonunion were painful. Union was induced by bone grafts. [ED. NOTE.—Disability might have been removed by resection.]

McMurray,[592] in discussing the apparent increase in the number of delayed unions in military surgery, suggests the use of the nonpadded plaster cast as one of the causes. He states that when a tight-fitting nonpadded cast is applied immediately after the fracture of such a bone as the tibia, the soft tissues are compressed against the bone, not permitting sufficient space for the formation of the physiologic blood clot which aids in the production of a normal amount of callus. He suggests postponing the application of the cast for several days to allow the formation and beginning organization of the blood clot.

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589. Ghormley, R. K.: Choice of Bone Graft Methods in Bone and Joint Surgery, Ann. Surg. **115**:427-434 (March) 1942.

590. Abbott, L. C., and Gill, G. G.: Use of Cancellous Bone Grafts in Orthopedic Surgery, in Medico-Surgical Tributes to Harold Brunn, Berkeley, Calif., University of California Press, 1942, pp. 1-11.

591. Leavitt, D. G.: Nonunion of Three Ribs, J. Bone & Joint Surg. **24**:932-936 (Oct.) 1942.

592. McMurray, T. P.: Delay in Union of Fracture, Brit. M. J. **1**:8-9 (Jan. 3) 1942.

PROGRESS IN ORTHOPEDIC SURGERY FOR 1942

PREFACE

In the preparation of this review of orthopedic surgery for 1942 the titles of 1,075 articles of orthopedic interest were selected from the *Quarterly Cumulative Index Medicus* for 1942. The number of articles reviewed and presented in this year's "Progress" is 627, or 59 per cent of the total. This is a higher percentage than in 1940 and 1941 (38 per cent and 34 per cent respectively), but the total number of articles selected this year for review is less than 1940 and 1941 (1,794 and 2,397 respectively). The smaller number of articles is due to the decrease in the volume of medical literature since the war commenced. As in the past two years, each editor has selected the articles for his section which he thinks represent the most progress and have the greatest scientific interest. The chairman or vice chairman of the editorial board has reviewed the material prepared for each section and has made certain additions and changes which seemed indicated to improve the publication as a whole.

On account of the war and the difficulties under which many of the editors have been working, the reviews of some of the sections have been slower in being returned to the chairman of the editorial board, and it was found impossible to send the whole "Progress" to the ARCHIVES OF SURGERY at one time. This has necessitated a change in the order of the sections. The preface could not be written until all sections had been submitted. It is believed, however, that in spite of the delay the quality of the reviews is up to standard and the publication will prove as valuable to its readers as the "Progress" of 1940 or of 1941.

Some of the editors last year were of the opinion that each section should have the name or names of those preparing it appearing with the section. This has been done in most instances. The members of the editorial board wish to thank again those physicians not members of the American Academy of Orthopedic Surgeons who have rendered such valuable assistance in the preparation of the material for the various sections. Special thanks are rendered to Colonel Jesse I. Sloat and his orthopedic staff at the Lawson General Hospital in Atlanta, Ga.; to Major Edward C. Holscher, Major Dudley W. Smith, Captain William P. Warner Jr. and Captain Lee Schlesinger for their part in the publication; to Captain Charles H. Wilson, of Orlando, Fla., and to all the others who have helped but whose names are not mentioned.

Both style and editorial comments have again been left to the discretion of the editors, except for a few changes made by the chairman of the editorial board. It should be stated again, however, as in the preface of the "Progress" of 1940 and of 1941: "If the reader or author of any article does not agree with the editorial comment, the editorial board hopes that he will think of the remark as only one man's impression and as in no way representing the opinion of the entire editorial board."

Owing to the fact that the chairman of the editorial board is in the armed forces, it was found necessary during the year to appoint a vice chairman, who has rendered most able assistance to the chairman and made it possible for the publication to appear on time.

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